A METHOD FOR DETERMINING THE PRODUCTIVITY OF PASTURE IN RELATION TO CROPLAND

by

RALPH ROBERT SCHLICHT

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INTRODUCTION

Pasture grasses and cultivated crops are rivals for the use of agricultural land. The problem of evaluating the productivity of pasturelands and comparing them with croplands had long presented one of the most difficult questions facing the farm manager or appraiser. As alternative land uses, they must be considered by anyone who would attempt to determine the productive value of agricultural land.

The farm manager, in making his decisions concerning the most profitable combination of the factors of production, must compare the returns to be expected from his lands when used for cultivated crops with those anticipated when the same land is used for pasture purposes.

Tax assessors, farm credit appraisers and prospective farm purchasers must place a monetary value on individual farm units. This value figure is affected by many factors, but the most important of these is the economic productivity of the unit considered. This economic productivity can be ascertained only after the alternative uses for the land have been considered and the anticipated returns from each use carefully determined.

Purpose

Information concerning the physical productivity and economic

rent to be expected from specific land types when utilized for pasture or cropland purposes would be of value in determining an economic classification of land. In general, it shall be the purpose of this paper: (1) to appraise any work of this nature which may have a practical application under Kansas conditions, (2) to consider methods and techniques for measuring the physical productivity of pastures and corresponding methods and approaches which would be helpful in obtaining comparable data for cropland uses, (3) to compare the respective physical units of product, (4) to develop a practical method or procedure to convert these physical yields and carrying capacities into economic measures and thus arrive at the value of specific land types when used for pasture as contrasted to their value when used for certain systems of crop production, and (5) to apply these measures or procedures to sample areas.

Scope

This paper will be concerned with only one of the many approaches to land classification. It will deal with a method for determining an economic rating for specific land types when used for pastures as compared with cultivated crops.

The major portion of the work has been confined to Nemaha County, Kansas, but applications of the method have been made in Allen County.

The systems of farm management, yields, prices and specific techniques were developed to meet the conditions existing in

Nemaha County and closely associated areas. They should not be applied to territories differing materially in physical resources or types of farming without modifications to meet local conditions and problems.

The general concept of the method and the basic approaches to the problem have a much broader application. Widely different areas may be evaluated and compared within themselves or with each other if the general approach and overall technique is applied to the specific management systems, yields and prices necessary to truly represent each of the divergent areas.

Method of Procedure

Methods and techniques developed in other states were reviewed and compared. A general plan of operation was determined, and an area in which to apply the method was selected.

The first step was to establish as accurately as possible the physical responses of the several land types to a given system of management. Lack of basic physical data on management systems and resulting variations in yields by land types limited variation of management methods for this study. The yields of crops and carrying capacity of pasture were determined by using productivity ratings for the individual land types, with average crop and pasture yields for the county.

The physical productivities of the land under the several major systems of land use were then compared and plotted against the ratings given the soils for each major use.

The second, and most revealing, part of the study was concerned with the determination of a method for the calculation of economic rent to the land types when devoted to alternative uses. A special application of the budget method was employed to make the step between physical yields and economic rent to the land. Standards as used in the farm management studies at the Kansas Agricultural Experiment Station were modified and adapted to the special requirements of the budgets when used for this purpose. Where no previous standards were applicable, special values, techniques and methods were developed to fill the needs of the study.

Budgets showing the anticipated gross income, expenses and resulting economic rent were prepared for each use of each land type for which physical data on yields were available.

The anticipated economic rents from the various land uses were then compared and final evaluations and comparisons of the several land types were completed.

An application of the method was made in Allen County.

Limitations

This type of economic land classification is limited by the physical productivity data available for the various land types. Verification of the productivity ratings by controlled yield tests in the field would tend to substantiate the results and would provide useful data concerning responses of the individual soils to management practices.

REVIEW OF LITERATURE

A study of the productivity of land must be based on information concerning the inherent productive capacity of that land under a given system of management. Barnes[1], in a discussion of soil productivity ratings and their use, says:

> The question of how much a farm will produce is the key question in evaluating systems of farming or types of farm organization and in valuing land, whether it be as a basis for taxation, credit, purchase or sale.
>
> The value of farm land depends, in large measure, on the income it can be expected to produce and this in turn depends much on the yield of the crops it can grow.

Kellogg[2], in discussing productivity ratings as applied to the individual land types as differentiated on a soil survey map, says:

> The productivity of a soil type (or phase) is the result of the combination of soil characteristics in relationship to the system of soil management. This productivity can be expressed in terms of yield and quality of crops under physically defined systems of management. It must be emphasized that to compare soil types as to productivity requires the careful definition of the management under which specific yields may be predicted. Provided the soil types and phases are properly defined, the concept of the productivity rating makes available a means for

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[1]C. P. Barnes, "Soil Productivity Ratings and Their Use." Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering. Memorandum No. 1, Beltsville, Maryland.

[2]Charles E. Kellogg, "The Contributions of Soil Science and Agronomy to Rural Land Classification." The Classification of Land. Missouri Agricultural Experiment Station Bulletin No. 421. December, 1940. p. 171.

synthesizing the great background of research work and experience in one figure of expected yield under a defined system of management.

Crop yields have been collected by a number of agencies including the Production and Marketing Association, State Agricultural Experiment Stations and the Soil Conservation Service. In some areas, individual farm records may be available for a period of years. In most cases, these records will not be by land types, but some of them can be used to devise or substantiate crop and pasture ratings for individual land types.

Information concerning the productivity or carrying capacity of pastures under Kansas conditions is particularly inadequate. Since pasture cannot be harvested in the manner of small grains and corn, a special measure of pasture production is needed. Estimates of pasture yields in Kansas are ordinarily related to ownership or political units and are not expressed in terms of the management system under which they were achieved. Carrying capacity ratings have been assigned to the pastures of Kansas by type-of-farming areas[3].

The Missouri Agricultural Experiment Station has conducted a study of the carrying capacity of pastures under Missouri conditions as measured by actual livestock production in the field. L'Hote[4] summarizes the method and technique as follows:

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[3]Carrying capacity ratings were assigned to each type-of farming area by a committee of Kansas Agricultural Experiment Station personnel, 1935.

[4]Homer J. L'Hote, "Measuring the Productive Value of Pastures." Missouri Agricultural Experiment Station Bulletin No. 443. May, 1942. p. 33.

> This study has been concerned mainly with the problem of working out a method of measuring the yields of various kinds of pasture. The method adopted embodies the determination of the feed requirement necessary to maintain the livestock, and to produce the gains and products on pasture. The feed fed while the animal is on pasture is deducted from this requirement and the residual is the amount contributed by the pasture and therefore measures the pasture yield.
>
> The yields secured on permanent pastures in a measure reflect differences in productivity of the soils on which they are grown.

The method used to evaluate grazing lands in the western range area is described in the handbook "Instructions for Range Surveys"[5]. This method has been used by the Production and Marketing Association in evaluating large pasture holdings in Kansas but it has referred to ownership units and was not broken down into a separate rating for individual land types.

When sufficiently detailed and dependable evaluations of the physical productivity of the land types have been provided, the second step in the method may be undertaken. This consists of the determination and comparison of economic productivity of land classes when used for pastures or for cultivated crops.

Kellogg and Ableiter[6] have devised a method of rural land classification for tax assessment purposes in North Dakota. Social land units (40 acre ownership tracts) were rated according to their physical productivity adjusted for distance from

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[5]Interagency Range Survey Committee, "Instructions for Range Surveys." United States Department of the Interior (Handbook). April 24, 1937.

[6]Charles E. Kellogg and J. Kenneth Ableiter, "A Method of Rural Land Classification." United States Department of Agriculture Technical Bulletin No. 469. February, 1935.

market and the result was presented in terms of a relative numerical rating for each social land unit. They summarize the method in the following words:

> For purposes of tax assessment, land classification must be detailed and clearly indicate any significant difference between social land units. The procedure for reaching this objective may be summarized under four general steps: (1) Accurate mapping (in detail) of the important physical features of the land, (2) the determination of the natural productivity of each important combination of these physical features (the natural land type), (3) the determination of the use group, or combination of use groups, to which the various social land units belong, and (4) the evaluation or rating of each individual tract of land according to its capabilities within its use group.
>
> The applicability of the method to other landscapes is briefly discussed. It is pointed out that the logic of the method probably has a wide adaptation but that, following this logic, the details of the method will vary in different landscapes.

The Montana Agricultural Experiment Station in cooperation with the Bureau of Agricultural Economics, United States Department of Agriculture has developed a method for determining the economic returns to the land and the tax paying ability of that land by broad land classes when used for alternate wheat and fallow and when used for the range production of cattle. Lord, Voelker and Gieseker[7] describe the procedure used in land classification and grading:

> Before land can be graded in terms of productivity, it is necessary to determine the uses which are physically and economically feasible. This is necessary in order that the expressions of productivity of the different

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[7] H. H. Lord, S. W. Voelker, and L. F. Gieseker, "Standards and Procedure for Classification and Valuation of Land for Assessment Purposes." Montana Agricultural Experiment Station Bulletin No. 404. 1942.

grades may have economic significance.

The first step in land classification for assessment is to estimate the productivity of the land for all probable uses. The anticipated annual gross return may then be computed by multiplying the expected price of the various products by the estimated productivity. Costs and other than land charges are then budgeted for the uses under consideration. The difference between these costs and the gross income is the annual amount available to support land charges. The land may then be classified according to that use which results in the highest net return to land.

It will be seen from this that classification and grading of agricultural land require reliable information concerning use, adaptability, and probable future productivity of the different kinds of land. This information can be secured from yield histories, soil surveys, and farmers' opinions. The best classification procedure will take all three types of information into consideration.

FUNDAMENTALS OF PHYSICAL PRODUCTIVITY STUDIES

The capacity of an agricultural soil to produce crops or pasturage under given conditions of management is the basic factor in the determination of its value. For purpose of physical comparisons, the actual yields or carrying capacities may be used directly. In the case of economic evaluations, the physical productivity data must be considered in conjunction with economic factors such as production costs, proximity to markets and relative prices.

This study will deal, first, with the determination of the physical product which may be expected under various management systems and, second, with the resulting economic productivity which may be expected when this physical productivity is used

with normal price and cost data.

Physical productivity data are of value in comparing the quantity of feed which may be expected from specific land types under several systems or organizations. They may be employed in land use adjustment studies or in the formulation of production programs such as those followed during the recent war. Farmers and ranchers may plan their livestock program to greater advantage if they know the physical production which may be expected from their soils when they are utilized for various combinations of crops or for pasture. When the physical capabilities of the respective land types have been determined, they may be employed as background for additional analysis in the determination of economic productivities. The latter use is of paramount importance in this study and has provided the major use for yields and carrying capacities of the individual land types.

Economic productivity ratings represent the ultimate goal in this study. Under the prevailing economic system in this country, the value of a capital good or the financial success of the farm business is measured by the income which it will provide. Competing land uses, modifications in type of farming and physical yields are important, primarily, inasfar as they influence the monetary return to be expected from the unit under consideration.

Basic Soil Survey

The first step in the determination of physical productivity in a given area must rest upon an adequate classification of the soils in terms of natural characteristics and inherent capabilities. Ableiter[8], in discussing soil types, says:

> The soil type thus represents a combination of characteristics that together occupy a particular kind of landscape in which the factors of soil genesis--climate, native vegetation, relief, parent material, and age or time--are essentially uniform.
>
> In short, the definition of a soil type comprehends all the internal and external characteristics of the soil, in their relationship to one another, that have a significant bearing upon the genesis of the soil, upon its capability for the growth of natural and cultural vegetation, and upon its functioning under cultural practices.

From this discussion, it becomes apparent that the land types should be delineated in sufficient detail to isolate any differences which would exercise an appreciable effect upon the productive ability of the soils under management systems prevailing in, or adapted to, the area. Economic conditions, such as anticipated costs and prices, must be considered in setting upon a system of soil survey for this purpose. Areas of low productivity may require only a generalized soil map, while highly productive areas will merit considerable attention

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[8] J. Kenneth Ableiter, "Productivity Ratings of Soil Types." The Classification of Land. Missouri Agricultural Experiment Station Bulletin No. 421. December, 1940. p. 14.

to details. For purposes of tax assessment, credit appraisal, farm purchase, or farm management, the classification should be sufficiently detailed to indicate any differences which would manifest themselves in yield variations or in costs necessary to produce a given quantity of product. Additional detail would not be necessary and would probably not pay for the extra cost incurred in obtaining it.

The land type map, as outlined above may be a general purpose map as delineated by the Bureau of Plant Industry Soil Survey. As such, it can be used in various studies ranging from a geologic classification of the parent materials to an economic productivity rating of the land types as delineated. If the general purpose soil classification map is not available, a special classification may be made to fit the needs of the study. This map would partake of the nature of the general maps insofar as the observable physical characteristics of the soil are of paramount importance in determining the productivity of that soil.

It may be desirable to group or subdivide the soil types as indicated in the basic soil map. These soil types are often determined for general purposes and may not provide a satisfactory breakdown for the investigator who is interested in comparative productivities. Soil types exhibiting a considerable range in slope and erosion are not sufficiently homogeneous to provide constant yields and should be subdivided. In other areas, several soil types may exhibit similar productive capacities and may be grouped into one class for purposes of

productivity comparisons. Special groupings for this purpose will be referred to as "land types" in this study.

Management Systems

In the discussion of crops, the term "management system" refers to the crops grown, rotations, ways in which the produce is utilized, methods of caring for and harvesting crops and similar considerations. In the pasture studies, management systems refer to similar considerations such as kind, number and proportion of livestock pastured and the methods by which they are handled and marketed, as well as the methods followed in caring for, preserving and utilizing the pasture land itself.

Significance of the Management System Employed. A soil may be described in terms of its profile, relief, texture, fertility level and similar characteristics. These features, together with the climate, determine the capacity of that soil to produce crops or pasturage. The actual yield in terms of bushels or tons of a given crop, or in carrying capacity per acre, cannot be determined until the management systems under which the soil is to be employed have been set forth.

No soil has productivity in the terms described above without some system of management. Even native grasses, growing on public range, without the aid of man, are not productive without a system of grazing by which the forage can be utilized. In this case, the time and manner of grazing and the kind, class,

and number of livestock employed make up the management system under which the yields of grass may be measured.

A physical or economic productivity rating is best expressed in terms of the specific products, or dollars of economic rent, which reasonably may be expected from a given soil under given conditions of management.

Significance of the Quality of Management. The ability of the individual manager to organize and supervise the operation of his unit will vary within management systems. This factor must be considered in evaluating yields or production figures from individual farm units.

Quality of management is also of importance in determining the physical production and economic rent which may be expected from a particular land type under given management systems. In this case, the general ability of the farm managers as a group must be considered. For purposes of this study, the quality of individual management has been held constant at, or slightly above, the general level which was estimated to prevail in Nemaha County.

Determining the System of Management. The management systems to be employed for productivity investigations may be selected with either of two general approaches in mind. They may be designed to duplicate, insofar as is possible, the actual conditions and practices which exist throughout the area being studied; or they may be selected with the objective of evaluating the land in terms of some hypothetical management system.

The evaluations may be made using an individual management system for each land type (or group of similar land types) or they may be set up using one system of management for all soils considered. In either situation, the management systems might be those existing at the time of the study or they might rest on some hypothetical basis.

Two of the preceding combinations have been employed to a considerable extent by investigators in this field. They will be discussed in some detail below.

Variable management systems for maximum return: The crops, rotations, methods and techniques may be selected with the objective of maximizing the total net return to the land. This approach allows the selection of several management systems, varying in intensity or in the proportion of the factors of production. The individual land types may be considered separately and managed differently, if their respective physical conditions should merit. The particular system which produces the highest economic rent to each land type, under constant price and cost relationships, would be selected as the system under which the particular land type would be rated. This method takes into consideration such factors as physical capabilities of the soils, the geographical location of the land and the comparative advantage of the several enterprises. It represents the best approach to a determination of the optimum management system and may be employed by farm operators in planning the farm business.

The use of variable management systems presents several difficulties when it is employed for practical work in the field of land classification. The first objection is directly concerned with the quantity of work necessary to carry out the classification. The second limitation is imposed by the fact that the basic physical productivity information concerning the responses of the soils to changing management systems is limited. The third objection is the fact that the farm managers on the land may not be handling the land types in the method determined by the relative economic returns under the management conditions assumed in calculating the budgets. The classification, in this case, would be somewhat hypothetical and might not represent the value of the land under contemporary conditions. The fourth weakness lies in the fact that land types occur intermingled with one another. In many cases, appreciably different land types occur in the same field and are handled in exactly the same manner. There is also a tendency, as recognized in type-of-farming classifications, for the management systems employed to be constant over relatively extensive areas (several counties).

Constant management systems: The management system under which the land is utilized may be based on the average of typical management practices, type of farming and general operational techniques which actually prevail in the area to be appraised. All soils are handled in a similar manner. This approach should result in yields and economic rents in keeping with those

realized by average farmers and ranchers under existing conditions. Assessors, credit agencies and similar parties are interested, primarily, in ratings determined in this manner. Theoretical economic rent to land may also be calculated under representative management systems using the average wages, costs, interest and prices prevailing in the community.

This method has been criticized on the basis that the management systems followed by individual farmers may not be homogeneous in nature. If this consideration is allowed to dominate the method, it is conceivable that a separate management system would have to be established for each general organization of farm. A breakdown of this nature would have certain merits insofar as each farm is considered in the light of its greatest comparative advantage. Under practical conditions, its desirable features would be outweighed by other considerations. If each farm were considered individually (or as part of a small group), the problems mentioned in the theoretical management systems would again become apparent. The selection of specific enterprises, the variations due to changing crop and livestock programs and a group of related limitations would again be presented. The limitations in personnel and time also would eliminate a study with this much detail.

A land classification, if it is to be of practical importance and wide application, must be restricted to a relatively simple technique. It would seem desirable to select a system

of management which represents the general approach taken by the majority of the farmers in the area to be rated. This is the same approach as that followed in delineating type-of-farming areas. The rotations, methods, techniques and practices would be in keeping with prevailing conditions and the management system would be general enough to apply to all, or at least a major portion, of the county.

If the unit under consideration consists of several type-of-farming areas, or if the management systems followed in one portion are materially different from those followed in the remainder of the area, more than one major management system will be necessary. If this situation exists, the land types in each type-of-farming area may be considered as a group, and the final comparisons of physical product or economic rent must be interpreted in terms of the management system employed in producing them.

If the objectives of the study being conducted should merit, some other combination of the factors mentioned above might be desirable.

Physical Productivity Ratings and Measurements

When the land types have been determined, each individual type must be evaluated in terms of the physical product which it may be expected to produce under each system of management. These ratings may be in terms of actual physical production as

"eight-bushel wheat land, under continuous cropping" or they may be in terms of a relative number along an arbitrary scale as "a relative rating of 60 with the best soil in the area rated as 100". The latter method has been most commonly used because it permits comparisons based on the adaptation of a given area to two or more crops whose physical productivity cannot be measured logically in the same unit. Examples are alfalfa and wheat, or corn and native pasture. The Bureau of Chemistry and Soils, United States Department of Agriculture, in making soil surveys, has found it useful to relate the rating number to a specific physical yield of each crop rated.[9] Thus, a rating of 100 for corn indicates that a 50 bushel yield of corn may be expected while a rating of 100 for wheat indicates that a 25 bushel yield of wheat may be expected. In this rating, the 50 bushel yield of corn represents the production which may be expected under prevailing management without amendments from the best corn soil of extensive distribution in the United States. The 25 bushel yield of wheat represents the yield of wheat which may be expected from the best wheat soil of extensive distribution in the United States.

It must be emphasized that a physical productivity rating or yield figure should be indicated in terms of the management system necessary for its production. Thus a productivity rating of 85 for pasture on a given land type must be interpreted in relationship to the management practices for which the land type was evaluated. To obtain a complete picture of the

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[9]Barnes, loc. cit., p. 6.

physical capabilities of the soils in an area, we must measure the yields of the different soils under constant management system and also measure the yield of each individual soil when handled in different ways.

The yield which may be obtained from a given land type represents the summation of all the characteristics of that soil, and serves as the most valuable indicator of usefulness for crop or livestock production. Because of this fact, all characteristics of a soil must be taken into consideration in arriving at a productivity rating.

Crops vary in their soil requirements. A good wheat soil may not provide optimum conditions for the production of corn. For this reason, it is desirable to rate most soils separately for each individual crop. Actual yield tests, when available, will provide information of this nature and the subjective ratings commonly provided in soil survey reports are stated in terms of adaptability of the soil for individual crops.

R. E. Storie, of the University of California, has developed a system of soil productivity ratings which has been of considerable practical importance under California conditions.[10] This system rates each land type as to its adaptability for the production of crops in general. Each soil is given a rating on the scale of 0 to 100. These ratings are based on profile, surface texture, slope and other modifying features. The method

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[10] R. E. Storie, "Index for Rating the Agricultural Value of Soils". California Agricultural Experiment Station Bulletin No. 556. July, 1944.

has some advantages in that it provides a more objective approach to evaluating the various features of the soil themselves.

Its major disadvantage lies in the fact that one rating does not provide enough specific information to indicate the adaptability of the soil for any one specific crop. This is particularly true in the case of native pasture. Land which has been given a low rating because of some feature such as stoniness, may be capable of producing excellent native pasture grass.

In areas of general crop production, the Storie Index will provide a reasonably satisfactory evaluation for crop land. A second index is necessary before the adaptability of the land for native pasture may be ascertained. This index could be calculated in the same manner as the first, but would have a different set of standards by which certain features of the land, such as slope and stoniness, would be rated.

Individual crop ratings may be used to provide all information obtainable from the general rating. In addition, they indicate the relative value of the soil when used for specific crops. If a rating for general crop production is desired, the individual crop ratings may be weighted according to their frequency of occurrence in a representative rotation and then averaged.

Productivity ratings should be stated in terms of specific physical yields if they are to be most useful in making economic evaluations of land. For example, a rating of 80 on a scale

of relative productivity values will have limited application until it is related to a definite yield or carrying capacity under clearly defined conditions of management.

A land type may be assigned a productivity rating by either of the two widely used techniques or by some combination of these methods. The first is based on a subjective evaluation of the characteristics of the soil such as topography, erosion, surface texture and profile. The estimated yield or rating is assigned in the light of past experience with soils exhibiting similar characteristics. In the second method, yields are determined by actual field tests or grazing experiments under given management. The two methods are discussed below.

Subjective Productivity Ratings. Subjective productivity ratings have been widely used in studies dealing with the productive capacity of land. They provide a fast and relatively inexpensive approach to a highly complex problem. Ordinarily, the ratings are made by a group of soil scientists who have had extensive experience with soils and the production which may be expected from them. Each land or soil type is evaluated in terms of its inherent physical characteristics. Experience gained in handling or observing similar soils is of wide application in preparing such a rating. Actual yields as shown in farm records or as determined in field tests may be used to substantiate these subjective ratings.

Yield Studies. The discussion of subjective productivity ratings has indicated the need for carefully controlled yield

tests or observations. The real measure of the capabilities of a soil is provided by the yields which it will produce when handled in a given manner over a long period of time. Actual yield tests, supplemented by yield data from farm records and government agencies, can be used to considerable advantage in verifying or correcting the ratings assigned in the subjective manner described above.

A carefully controlled study is being conducted to determine the yield which may be expected from each of the major land types under varying conditions of management in Geary County.[11] Subjective productivity ratings have been attached to the major land types and the dependability or accuracy of these ratings is being checked by actual physical yield information. Data from this study were not available in time to serve as the basis for this paper, but should be of considerable value to succeeding studies.

It is felt that the subjective ratings provide an immediate approach to the problem of rating a particular area. As time and resources become available, additional information can be compiled for the purpose of verifying or modifying the subjective ratings. Until these yield studies are made, the existing ratings must be used as the best available measure of soil productivity.

Measurement of cropland productivity: Cropland productivity

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[11] W. H. Pine, "Method of Classifying Kansas Land According to Economic Productivity." Kansas Agricultural Experiment Station Unpublished Report, Project 215. 1947.

may ordinarily be measured in terms of bushels or tons of product. These measurements may be made by harvesting representative samples or by careful observation and measurement of the product produced under farm conditions.

Some difficulty is encountered in measuring the yields of such crops as sweet clover and sudan grass when utilized for temporary pasture purposes. At the present time little information is available on this specific land use. Attempts to measure temporary pasture productivity should be conducted in the same way as the native pasture studies described below.

Measurement of pasture productivity: Information dealing with the productivity of pastures is particularly deficient. Since pasture land ordinarily may be harvested only with livestock, the conventional measures of yield are of little significance. Some measure must be devised which is adapted to this peculiar condition.

The gains sustained by the livestock, as well as the price which will be realized when they are sold, depend to a considerable extent upon the class, age and condition of the animals maintained. Younger animals will show greater gains than mature animals. Thin animals will show greater gains than animals carrying some degree of finish. Given the same amount of pasturage, high quality dairy cows will produce greater quantities of milk than will low producers.

Grazing practices exert a considerable influence upon the quantity and quality of forage which may be obtained from a

pasture. Rotation grazing, careful distribution of water and salt, weed eradication, careful timing of early spring grazing and similar management practices will aid materially in increasing the yields of pasture. These factors, the kind of animal and grazing management, must be clearly defined before the production indicated will be of any great value in appraising the particular land type as a pasture soil.

Under farm conditions, pastures may be utilized by any or all ages of livestock; beef animals, dairy animals, work animals, or sheep. The problem of measuring productivity under these conditions is complicated by the difference in units by which the product is measured.

Three general approaches have been made to the problem of measuring pasture productivity.

The first, and oldest, is the subjective estimate of the pasture yield in the light of the observer's previous experience. This method has been developed and applied with a score card by the Department of the Interior Range Survey.[12] In this system, the grassland is evaluated in terms of its plant composition, density of vegetation and relative proportion of the forage which may be consumed without injuring the range. This rating is used in conjunction with a figure representing the amount of forage which will be necessary to support one animal unit under local conditions. The final evaluation is presented

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[12] Interagency Range Survey Committee, op. cit.

in terms of carrying capacity, or number of acres of pasture necessary to support an animal unit for a given period of time. This approach has been used extensively by the Production and Marketing Administration in their range survey of Kansas pastures.[13] It is relatively easy to obtain and can be useful in planning grazing operations. Since it has been applied to land types as such, no specific information concerning carrying capacity is available from these sources in Kansas.

The subjective rating approach has been employed by the Production and Marketing Administration in Geary County.[14] The county committee has made an evaluation of individual land holdings by ownership units and assigned a carrying capacity rating to each. These ratings have not been available in terms of land types and were not applicable to this study.

The second major approach to the problem of measuring pasture productivity has been the use of quadrat surveys. This method involves the protection of representative samples of the area being evaluated. The forage produced on these protected areas is clipped at intervals and weighed. The yield is determined by the quantity and quality of the grass, or grass and weed mixture, which makes up the pasture flora. Agronomists have used this technique extensively in studying

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[13]Information gathered by inspection of Kansas State Production and Marketing Association files, Manhattan, Kansas, November, 1946.

[14]Information gathered by inspection of Geary County Production and Marketing Association files, Junction City, Kansas, December, 1946.

responses of pasture to varying management practices. It provides an excellent appraisal of physical pasture productivity but is handicapped by the high cost and may be limited by the difficulty of selecting representative samples.

The third major approach to the measurement of pasture yields has been based on the utilization of the forage by livestock under practical farm or ranch conditions.[15] This technique provides a highly realistic measure of physical pasture productivity. The yields are presented in terms of pounds of beef produced, pounds of milk produced or similar measurements. The practical applicability of these measurements is appreciably greater than that of the yields provided by the quadrat method as no conversion factor is necessary to change the yield of grass to equivalent production of animal products. Because of the extensive record keeping necessary for this approach and the high cost of conducting controlled experiments, it has not been used in any extensive evaluation of pasture carrying capacity by land types. No records of this nature are available for Kansas soils.

A practical technique for the measurement of pasture yields should provide for a combination of these three methods. The individual land types could be evaluated by the subjective method, using the system described for the Range Survey. Representative samples of these areas would then be clipped and the clippings weighed, thus providing benchmarks to which the

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[15] L'Hote, loc. cit.

subjective ratings could be compared. Actual yield tests employing farm livestock could be conducted on a limited scale to determine just what the production of animal products would be on land types meriting a given subjective rating or producing a given weight of a specific kind of forage per acre. This method would provide for the combination of an extensive approach with accurately measured benchmarks to which subjective ratings could be compared. A maximum area could be accurately evaluated with a minimum of time and effort. An approach of this nature should be of considerable value under Kansas conditions.

The question of management systems and quality of management is one of the most difficult problems facing the person who proposes to rate the productive capacity of land in native pasture. A pasture's carrying capacity is influenced not only by the present quality of management and management system, but by the treatment which it has received over the preceding years. Thus, a pasture on highly desirable soil, under excellent conditions of current management, may afford a low yield because it was overgrazed and allowed to grow up in weeds during the preceding period. Any evaluation of feed available, animal products produced, or even the general appearance of the grass, must be made in the light of present and preceding management. If comparable ratings for pasture soils are to be obtained, the conditions of management must be held constant.

APPLICATION OF THE METHOD

Soil Surveys Available for Productivity Studies

Several agencies have classified soils in the field and recorded their classifications in the form of soils maps. Some of these classifications have been made for special purposes and are of limited direct value in delineating soils of comparable productive capacity. Surveys showing broad general classes of soils, or indicating the areas in crops, pasture and woodland are of this nature. Others may divide the soils into groups of comparable productivity but do not include productivity ratings for the individual land classes.

This latter group may be useful in conducting a productivity study but before they can be utilized, each individual land or soil type must be evaluated in terms of its capacity to produce crops and pasturage. It must be assigned a productivity rating.

Time and resources for this study did not permit the use of surveys which did not carry productivity ratings. The surveys which do provide this information are discussed below. The most common distinction between the studies indicated is the amount of detail with which the individual land types (or soil types, depending upon the nature and objective of the survey) are delineated.

Detailed Surveys. Soil Survey Reports completed by the Bureau of Plant Industry, in cooperation with the state experiment stations are available for a few counties.[16] These surveys have been conducted for a number of years and those made at different periods show considerable variation in detail of classification and in supplementary information included. In general, the surveys break the land down into series, types and phases as outlined in the study of Allen County, Kansas.[17]

The more recent of these studies carry a table rating each of the major soils of the county according to the yields of commonly grown crops which may be expected under prevailing management systems. These estimated yields are checked by any information available as to actual yields. If the experience of farmers has supplied sufficient information, the estimated yields are given in terms of more than one management system. Thus the yields indicated may be classified according to "good", "average", or "poor" management systems. In some reports, a special rating is provided for certain soils when they have received a recommended application of fertilizer. The estimated yield of each crop also is converted into an index by calculating what percentage it is of a standard yield. The mean of the indexes for each soil is computed (either with or

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[16] Barnes, loc. cit., p. 1.

[17] W. I. Watkins, W. H. Metzger and J. R. Latta, "Allen County, Kansas." Soil Survey. United States Department of Agriculture, Bureau of Chemistry and Soils in cooperation with the Kansas Agricultural Experiment Station, 1938.

without weighting the indexes) and the soils are arrayed or grouped according to their average indexes.

Reports of this nature are of considerable value in determining the physical and economic productivity of soil types. A greater refinement of yields to be expected under varying conditions of management would be useful. Additional verification of the subjective yield estimates would make the results of the studies more dependable. This is particularly true of pasture ratings.

Reconnaissance Surveys. The term reconnaissance survey is used to indicate those studies which do not break down the soils to a degree comparable with the detailed surveys. The most general of these may involve a traverse of the area at intervals up to four miles while the more thorough work may approximate the detailed surveys in the accuracy with which the characteristics of the soils are observed and recorded.

Reconnaissance surveys conducted by the Soil Conservation Service are available for a number of Kansas counties but are not of immediate value to this study because they do not carry productivity ratings for the soils as delineated.

Semi-Detailed Surveys. An extensive area analysis and agricultural adjustment study was completed in Nemaha County, Kansas, in 1942.[18] A semi-detailed survey delineating the soils on the basis of land types was made for the county.

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[18] W. H. Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." Kansas Agricultural Experiment Station Bulletin No. 305. October, 1942.

Each soil was assigned a rating in relationship to its capacity to produce each of the crops common to the county. Additional information concerning land use, financial condition of farmers, production costs and management systems is available for the county. It provides a source of information which is of considerable value in determining representative management systems, costs and returns to each land type when utilized for pasture or for a system of cultivated crops.

The following is a description of the land areas and the productivity ratings for Nemaha County as provided by Kansas Agricultural Experiment Station Bulletin No. 305:

> The soil survey used for this study is in the nature of a general land type survey. Although classed as a reconnaissance, it approximates a semi-detailed survey. Separations in this survey were made mainly on the basis of major characteristics significant to plant adaptation and farming practices. Soil characteristics were noted with respect to location (upland or bottom land), parent material, depth of surface soil, depth to lime carbonate horizon, dominant characteristics of surface soil and subsoil, and subsoil consistency. Degree of slope was noted and expressed in significant percentage intervals, and the degree of erosion which the soil had undergone was expressed in qualitative terms.
>
> An agronomic evaluation of the land types was made by field inspection. This inspection was made by a group of soil scientists, agronomists, and agricultural economists. The agricultural extension agent and farmers of Nemaha county were consulted. The land type which would yield the highest under customary farming practices in the county was given a rating of 100 for the particular crop under consideration. Other land types were rated in terms of the percentage that would best express the ratio of the yielding capacity of the land under consideration to that given a rating of 100. Each land type was rated for each of the major crops grown in the area.

The percentage distribution of the land in farms according

to land type and the percentage of each land type in native pasture are shown in Table 1.

Land types and productivity ratings for pasture and for the crops commonly grown in the county are shown in Table 2.

Table 1. Percentage distribution of the land in farms according to land type and percentage of each land type in pasture, Nemaha County, Kansas.

Land type	Percent of land	Approximate percentage of each land type in pasture/1
1	3.75	4.24
11	23.96	11.77
2	17.64	21.37
21	1.46	50.48
22	.73	76.83
23	12.78	27.84
231	6.32	36.27
24	7.06	45.49
25	3.38	57.01
3	1.47	19.34
31	1.33	39.99
32	1.18	45.43
33	.33	32.32
4-41	17.71	48.50
Total	100.00	37.36

[1]Determined from a sample of 80 sections from the 1939 land use survey in Nemaha County. Includes woodland and woodland pasture.

Table 2. Evaluation of land types according to productive capacity, Nemaha County, Kansas.[1]

Land type	Relative evaluation (100 equal highest productive capacity for county)						
	Corn	Wheat	Oats	Alfalfa	Sorghums	Sweet clover	Native pasture
1	90	100	100	85	90	90	100
11	80	90	90	75	80	85	85
2	60	65	70	50	65	70	60
21	20	30	35	20	25	40	45
22[2]							40
231	35	35	40	25	50	50	40
23	60	50	60	50	65	90	60
24	50	40	50	35	60	60	50
25	25	25	30	15	25	50	50
3	75	70	75	80	90	100	100
31[2]							75
32[2]							50
33[2]							55
4-41[3]	98	75	72	97	98	87	92
County average[4]	70.0	65.0	71.0	60.1	70.4	--	72.6

[1]From W. H. Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." Kansas Agricultural Experiment Station Bulletin No. 305. October, 1942. Ratings were made by an experiment station committee of economists and agronomists assisted by representatives of the Soil Conservation Service. They were based on a visual inspection of the areas and on yield data available for the county.

[2]Not evaluated for crops because of its low productive capacity.

[3]The bottom land soils were combined because the information concerning location of crops grown did not differentiate between them. The rating shown represents a weighted average of the ratings for the separate soils.

[4]Average of individual productivity ratings weighted according to the relative area of the crop on each land type.

Selection of an Area for Study

The determination of physical and economic productivities rests upon an adequate physical inventory of the land area to be evaluated. The factors considered in selecting the study which was to serve as the basis for this paper are discussed below.

Nemaha County Study. Nemaha County, Kansas, was selected as an area in which the method for determining the productivity of pastures in relation to cropland could be developed. The Nemaha County study fulfills most of the requirements for a satisfactory land classification as described above. It provides a semidetailed soils map which delineates land types in terms of the physical characteristics which influence their capacity to produce crops and pasture under management conditions prevailing in the county. The soils are divided in sufficient detail to make the resulting information useful to individual farm operators or to others who are interested in small land holdings. Productivity ratings are supplied for native pasture and for each of the crops which are commonly grown in the county.

The work on area analysis and agricultural adjustments in Nemaha County provided information pertinent to conditions existing in the county. A complete breakdown of the area by

land types and kind of crop grown was available for 1939.[19] Standards and values for the calculation of farm budgets have been developed to represent this specific area. Several budgets representing typical farm organizations were available for each of the agricultural areas into which the county is divided. Information concerning management systems and techniques followed by farmers was available in greater detail for this county than in any other comparable area which might have been considered in Kansas.

The area analysis and adjustment study in Nemaha County is subject to certain limitations. The dependability of the productivity ratings developed for the study would be increased if additional information on yields and carrying capacities could be made available. This is particularly true for native pasture evaluations.

The ratings presented are made in terms of what was estimated to be the prevailing system of management in the county. We must assume, in evaluating the soils, that the cultural practices, fertilizer applications and similar considerations are uniform throughout the area. The study of Nemaha County conditions indicates that the practices do not differ materially in this respect and the limitation is not a serious one. In other counties, the variation in practices might necessitate a breakdown into two or more areas of greater homogeneity.

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[19]This information was determined as a part of the area analysis study in Nemaha County, Kansas. 1939.

The actual yields which may be expected are not calculated by land types. Information is provided which indicates the yields of the common crops by groups of more or less similar land types. These land type groups were too broad for purposes of a detailed productivity comparison but the method by which the yields were calculated has been employed in determining the yields by individual land types.

Several of the land types have not been rated for crops because of their low physical productivity. This has prevented a complete analysis of all soils in the area. Fortunately, these unrated soils comprise a relatively small portion of the county.

Alternative Areas. The soil survey for Allen County provided most of the essential information necessary for the preparation of physical and economic productivity comparisons. It was not selected for the original study because the information concerning land use, management systems, and practices was limited and the county did not appear to be as homogeneous in regard to the rotations and systems of farm management followed as was Nemaha County. A preliminary application of the method has been made to Allen County and is included in the Appendix.

An extensive study dealing with the classification and rating of soils according to the Storie system is now in progress in Geary County, Kansas.[20] This study should provide

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[20]Pine, "Method of Classifying Kansas Land According to Economic Productivity." loc. cit.

excellent data for comparisons of this nature, but at the time this work was undertaken, figures for yields of specific crops and pasture were not available.

Management Systems Employed

The management practices employed in this study represent a combination of the two approaches mentioned under the heading "Management Systems". They have been selected with the intention of equaling or slightly improving the management systems which were estimated to exist at the time of the Nemaha County study. The final physical and economic productivity ratings should be comparable with the results which are being obtained by farmers throughout the county. In order that variations in crops grown might be considered in the evaluation, two rotations have been used for cropland. One system of management has been used for temporary pasture and one system has been used for native pasture. The general quality of management has been held constant for all land uses and management systems.

The same techniques and practices have been assumed in calculating physical and economic productivity. The yields presented in Table 4 were used as basic physical information in calculating economic rent to the land.

Economic considerations are of prime importance in determining the management system to be employed. In spite of the

fact that physical production must be known before economic rent can be determined, the economic factors must be given major consideration in selecting the management system under which the physical yields or carrying capacities are determined. This matter will be discussed at greater length under the determination of economic productivity.

Management System for Cropland. The rotation followed on Land Types 1, 11, 2, 21, 23, 25 and 4-41 has been: corn, corn, corn, wheat, wheat, oats, corn, corn, corn, wheat, wheat, oats, alfalfa, alfalfa, alfalfa, alfalfa, in a 16-year rotation. The rotation followed on Land Types 231, 24 and 3 has been similar except that grain sorghums have replaced corn. The corn is produced on the bottom land and more productive upland soils while the sorghums ordinarily are produced on the poorer upland soils. These rotations are based on recommendations prepared for the soils of Nemaha County by the Department of Agronomy, Kansas Agricultural Experiment Station.[21] They approach the actual acreages as produced in the county but place more emphasis on the utilization of legumes in the rotations. In a sample of 80 sections made in the 1939 land-use survey of Nemaha County, the percentage of total crop land in each crop was: corn and sorghums, 48%; wheat, 22%; oats, 6%; legumes, 14%.

Alfalfa has been used as the only legume in the rotation.

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[21] Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." loc. cit., p. 10.

This should not be the case in actual practice but until information is available as to the amount of physical production which can be expected from such crops as sweet clover, comparisons of this nature must depend upon crops which can be harvested and evaluated. Several of the poorer upland soils of the county carry a higher rating for sweet clover than they do for alfalfa (Table 2). The alfalfa yields for these soils may be slightly lower than the production which could be expected from the sweet clover which is commonly used as pasture. The difference was not considered to be important for the purposes of this study.

Management System for Pastures. The pasturing of yearling beef steers during the grazing season was selected as a representative system of pasture management. This line of production was selected for several reasons: (1) It is typical of the management practice followed by a number of pasture owners in the county. (2) The use of beef animals is one of the most common methods of utilizing grazing land. (3) The employment of beef steers as a device for determining the yielding ability of pasture has been a common practice by investigators. (4) Information concerning the gains, market prices, costs and handling charges is more homogeneous, more readily available and can be employed with less modification than standards concerning dairy animals or sheep. The use of young steers should be the simplest and most widely applicable measure of pasture yields available under present conditions.

Methods of handling the pastures and steers will be discussed more fully under economic productivity calculations.

The production of beef per animal unit was considered to be 230 pounds per grazing season.[22] This gain would vary with the age, quality and finish of the animals, but represents an average production which could be expected over the country when four acres of average pasture land are allotted to each steer.

For purposes of farm management or highly detailed surveys, the kind and age of livestock might be varied as well as the treatment accorded the grass itself. This method would require basic physical data which are not available at this time and would lose the advantage of simplicity.

Under range conditions, the production of stocker calves might be selected as a typical enterprise. This would require the measurement of the pasture productivity in terms of number, weight and quality of calves produced per grazing season. The procedure has been used in the determination of a method for the valuation of livestock ranch properties and grazing lands in Montana.[23]

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[22] R. J. Doll, H. J. Meenon, J. A. Hodges and W. H. Pine, "Methods and Practices Used in Producing Beef Cattle in Chase and Lyon Counties." Kansas Agricultural Experiment Station Agricultural Economics Report No. 10. November, 1941.

[23] M. H. Saunderson, "A Method for the Valuation of Livestock Ranch Properties and Grazing Lands." Montana State College Agricultural Experiment Station Mimeographed Circular No. 6. March, 1938.

Determination of Physical Productivity

Cultivated Crops. When information concerning the natural capabilities of the land has been interpreted and a system of management has been selected, the actual yields which may be expected can be determined.

Establishment of individual crop yields: The productivity ratings for the crops commonly grown in Nemaha County are shown in Table 2. These ratings are relative and cannot be interpreted directly as yields for the crops in question. They do show the relationship between the capacities of the several land types to produce under the conditions of management prevailing in the county.

Crop yields were calculated for each land type. The productivity ratings were used in conjunction with the long time average yields as reported by the Kansas State Board of Agriculture.[24] A complete breakdown of the area in each crop was available by land types for the year 1939. For example, this information indicated that 5.5% of the corn grown in Nemaha County in 1939 was produced on Land Type 1. The individual land type ratings for a given crop were weighted by the proportion of the acreage of that specific crop which was produced on the respective land types and these weighted ratings

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[24] Kansas State Board of Agriculture. Biennial Reports. Topeka, Kansas.

were averaged to provide a productivity rating which would represent the average productive capacity of the land in that crop. The land type ratings were weighted by the acreage of the crop on each land type to prevent the ratings for land types upon which the crop was of little importance, or which were small in area, from carrying the same weight in the county average as those soils upon which the major portion of the crop was produced. The county average rating was set equal to 100 and the ratings for the individual land types were expressed as relatives to this figure. The relative rating for each soil was then multiplied by the average long time county yield of that crop to give the estimated yields by land types.

The method is illustrated by the calculation of corn grain yields as shown in Table 3. This method was used to arrive at a specific yield figure for each of the commonly grown crops on each land type for which productivity ratings were available.

Yields which may be expected from each of the crops commonly produced in the county are presented by land types in Table 4.

These yields assume constant management systems and quality of management for all land types at the level prevailing throughout the county. They do not show yield changes when fertilizers are applied nor do they show yields under management systems substantially different from those prevailing in the county.

If more physical data were available, methods and yields might be varied to provide multiple ratings of this nature. Such ratings would provide enough information to allow the different land types to be handled in different ways with the idea of maximizing the economic rent for each.

Table 3. Method of estimating corn yields by land types, Nemaha County, Kansas.

Land type	Land type rating for corn/1	Weight of land type in corn/2	Product	Relative rating for corn/3	Yield in bushels corn per acre/4
1	90	2.872	258.48	129	28.25
11	80	15.876	1270.08	114	24.96
2	60	9.562	573.72	86	18.83
21	20	.568	11.36	29	6.35
22/5		.170			
23	60	6.353	381.18	86	18.83
231	35	2.710	94.85	50	10.95
24	50	3.270	163.50	72	15.77
25	25	.999	24.98	36	7.88
3	75	.610	45.75	107	23.43
31/5		.414			
32/5		.167			
33/5		.137			
4-41	98	8.366	819.87	140	30.66
Total		52.074	3643.77		
Average rating		(weighted)	69.97	"100"	
Average yield					21.9

[1]From W. H. Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." Kansas Agricultural Experiment Station Bulletin No. 305. October, 1942.

[2]Weight in grams of the segments of a map, proportional to the acreage of each land type in corn in 1939.

[3]Relative rating for corn with the average soil of the county set equal to 100.

[4]Obtained by multiplying the relative rating for corn by the average county corn yield.

[5]Not evaluated for crops because of its low productive capacity.

Table 4. Estimated crop yields by land types, Nemaha County, Kansas.[1]

Land type	Yields per acre[2]						
	Bushels				Tons		
	Corn	Wheat	Oats	Sorghum grain	Alfalfa	Corn stover	Sorghum stover
1	28.3	25.9	36.8	28.9	3.55	2.58	3.33
11	25.0	23.2	33.1	25.8	3.12	2.28	2.96
2	18.8	16.8	25.8	20.8	2.08	1.72	2.39
21	6.4	7.7	12.8	8.1	.82	.58	.94
22[3]							
231	11.0	9.1	14.6	16.0	1.05	1.00	1.85
23	18.8	12.9	22.2	20.8	2.08	1.72	2.39
24	15.8	10.4	18.5	19.2	1.45	1.44	2.21
25	7.9	6.4	11.0	8.1	.62	.72	.94
3	23.4	18.1	27.7	28.9	3.32	2.14	3.33
31[3]							
32[3]							
33[3]							
4-41	30.7	19.5	26.6	31.4	4.05	2.80	3.61
County av.[4]	21.9	16.8	26.1	22.6	2.5	2.0	2.6

[1]Computed by using a long-time average yield with the productivity ratings.

[2]Under constant management equivalent to the management prevailing throughout the county over the period used in calculating the average yields.

[3]Not evaluated for crops because of its low productive capacity.

[4]Long-time average county yields.

It should be emphasized, however, that the individual land types occur in the same fields and are often handled in exactly the same manner under practical conditions. It should also be emphasized that for some approaches to the problem of productivity, considerable importance may be attached to the condition that all land types be managed in the same way.

The method described above has several limitations. The breakdown of crop production by land types as shown by the study was available for only one year, 1939. The average productivity as calculated for the county, and the resulting yields by land types, are accurate, only if the information as to the typical soil upon which each crop was grown represents the situation existing during the period over which the average yields were calculated. Crop acreages in Nemaha County for 1939 were typical of the county and fully satisfactory in most respects except for the relationship of wheat to corn. The acreage of wheat was relatively high and the acreage of corn was relatively low for this season as compared to long time averages. A short study comparing the change in yield with the change in acreage of corn and the trend in the yield of corn was undertaken. There was not enough evidence to justify any adjustments in yields and the distribution in 1939 was considered satisfactory for yield study purposes.[25]

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[25]Karl Shoemaker and W. H. Pine, "Relation of Corn Yields to Changes in Acreage, Temperature, and Rainfall, and the Trends in Corn Yields in Nemaha County, Kansas." Kansas Agricultural Experiment Station Department of Agricultural Economics. Unpublished report. 1940.

Information which would indicate the average soil upon which each crop is grown over a period of years would be desirable for an approach of this sort.

The second limitation is concerned with the possibility that yields for specific crops may not continue at the same level as indicated by historical data. This objection may be raised when any historical data are used to forecast or estimate future conditions. If the historical information is carefully appraised and the estimate for the future is made in the light of future conditions, as compared to conditions in the past, this type of information becomes one of the most valuable aids in the planning of future operations. Crop yields in Nemaha County have remained relatively constant for the past 40 years as shown by the reports of the State Board of Agriculture.[26] Improved varieties, such as hybrid corn, together with improved cultural practices, more efficient operation and improved management systems, have been offset by the decreasing fertility of the soil. The net result has been relatively constant yields over the period.

This study is based on a system of management which approaches that existing throughout the county. Under these conditions, it seems probable that the crop yields will not change appreciably during the next few years.

Combination of individual yields to obtain total production: When the yields of each crop have been established

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[26]Kansas State Board of Agriculture. op. cit.

for each land type under the system of management which has been selected, the individual yields may be converted to a common unit of production and averaged. This average figure will represent the normal production of the specific land type in terms which may be used for comparisons with other land uses.

The individual crops grown in the rotation vary appreciably as to the total nutrients supplied by a normal yield. Thus, an average crop of alfalfa will provide more nutrients than will an average crop of oats. For this reason, it is necessary to convert the yields of each specific crop to a common unit and calculate the average production which could be expected when the various crops are used in a rotation.

The first step in calculating total production is the conversion of unlike products to a common unit. Total physical production per acre when used for crop according to the management system outlined above, was determined by converting the production of each crop to an equivalent quantity of corn. These corn equivalents were weighted according to the frequency of the particular crop in the rotation to determine the average physical production. Conversion factors for the expression of unlike feed units in terms of corn equivalent were provided by Morrison's feeding standards.[27] The conversion factors are based on the therms of net energy contained in each

[27] F. B. Morrison, Feeds and Feeding (Ithaca, New York, c. 1936).

feedstuff and enable each individual crop product to be expressed in terms of corn. The conversion factors employed are as follows:

Corn (bu.)	1.000	bushels	No. 2	yellow	corn	
Wheat (bu.)	1.146	"	"	"	"	"
Oats (bu.)	0.468	"	"	"	"	"
Alfalfa (ton)	18.715	"	"	"	"	"
Serghum grain (bu.)	0.950	"	"	"	"	"
Stover (ton)	5.614	"	"	"	"	"
One acre average wheat pasture	1.670	"	"	"	"	"

The corn equivalents of each crop when produced on Land Type 2 are: corn, 22.05; wheat, 21.92; oats, 12.09; alfalfa, 38.83. A similar calculation was made for each of the soils. The average production in corn equivalent was determined by weighting the yields according to the frequency of occurrence in the rotation and averaging.

The conversion of standard yields such as bushels of wheat or tons of alfalfa to corn equivalent is a relatively exact procedure. The evaluation of products such as wheat pasture and stover presents a more complicated problem. The actual feeding values are less standardized and the problem is further complicated by the fact that under prevailing management conditions, a considerable quantity of such feeds may be wasted.

In determining the physical production of the corn and serghum stover, the weight of stover produced was calculated for each land type. This quantity was included in the total production at 30 percent the value of an equal weight of alfalfa. The comparative value of the stover was based on

standards used in production adjustment studies at the Kansas Agricultural Experiment Station.[28] It allows for the fact that stover is inferior to alfalfa as a feedstuff and also considers the fact that under farm conditions in Kansas, the stover produced is only partially utilized. This evaluation will be discussed at greater length when the economic productivity of cropland is determined.

The wheat pasture was assigned a value in keeping with the evaluations of average wheat pasture in this region as determined by the same production adjustment studies. The fact that wheat pasture is not fully utilized under farm conditions, is considered in the rating.

When the yields which may be expected from each crop have been converted to an equivalent amount of corn, the individual corn equivalents may be weighted according to the frequency in the rotation and averaged. This value represents the average production of the soil for the management system employed. It is not the production of any one particular crop and depends upon the rotation used. Thus, a management system employing only alfalfa would yield appreciably more physical product than one employing only oats. This consideration is of some importance in determining the rotation to be used for purposes of evaluating the land types. If the physical product is to be compared, the crops used on the soils being

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[28] Production Adjustment Studies, Kansas Agricultural Experiment Station, Department of Agricultural Economics. Unpublished material.

compared should have about the same percentage of roughage producing crops or the relationships may be distorted.

The specific operations performed and the details concerning production and disposal of crops are discussed under the determination of economic productivity as economic factors have a prime bearing in their selection.

The corn equivalent produced on each land type in Nemaha County when utilized for cultivated crops is shown in Table 5.

Native Pasture. Carrying capacity of native pasture by land types was calculated in the same manner as were the yields of individual crops. Information was available to indicate the percentage of the total pasture area of the county which was located on each land type. The average yield for pasture was based on an average carrying capacity of four acres per animal unit.[29] This yield was determined by a committee of Kansas Agricultural Experiment Station personnel and has been used extensively for area analysis and adjustment studies in Nemaha County and surrounding areas.

In making the rating, pasture production was estimated in terms of prevailing management practices and prevailing methods and techniques as well as by the general conditions of the pasture grasses.

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[29] Ibid.

Table 5. General crop rating, corn equivalent produced, and estimated beef production per acre in crops, Nemaha County, Kansas

Land type	General crop rating/1	Estimated corn equivalent produced per acre (bu.)/2	Estimated production of beef per acre in crops (lbs.)/3
1	92	42.8	300
11	82	37.9	266
2	60	27.1	190
21	24	10.6	74
22			
23	55	25.7	180
231	39	18.2	127
24	48	22.6	158
25	23	10.0	70
3	81	41.2	288
31			
32			
33			
4-41	88	44.2	309
County average	65	30.7	215

[1]Average of the ratings for individual crops weighted according to the frequency of occurrence in a representative rotation.

[2]Estimated production of the individual crops was converted to corn equivalent (F. B. Morrison, Feeds and Feeding. Ithaca, New York, c. 1936. pp. 953-1000.) and weighted according to the frequency of occurrence in the representative rotation.

[3]One bushel of corn equivalent will produce approximately 7# of beef when utilized by steers weighing between 400 and 1000#. (Morrison's Feeds and Feeding. p. 643.)

The ratings and carrying capacities of the several land types when utilized for native pasture are shown in Table 6. The carrying capacity is directly proportional to the pasture rating for the land type. The pounds of beef produced per acre were calculated according to the management system described above. The beef produced by each land type is shown in the right hand column of Table 6.

Temporary Pasture. The use of cropland for temporary pasture purposes has been a common practice in Nemaha County.[30] This is particularly true of dairy farms. The yield of sweet clover, sudan and similar crops when utilized in this manner also can be measured by the quantity of beef produced.

The method of utilizing temporary pasture as used in this study should prove satisfactory, but the gains of the steers are based on approximate yields and should receive further verification. The Kansas Agricultural Experiment Station has used the relationship of three to one in comparing the carrying capacity of temporary pastures to native pastures. Obviously, the yield of temporary pasture on a given soil will not always be three times the yield of that soil if utilized for native pasture. This is due to the fact that the yield of temporary pasture is related to the crop ratings while the yield of native pasture is related to the pasture ratings.

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[30]The sample area of 80 sections which was planimetered as a part of the Nemaha County study indicated that 5.48 percent of the cropland in Nemaha County was in sweet clover. The area in sudan and other temporary pasture crops was not determined.

Table 6. Relative rating, estimated carrying capacity and estimated beef production per acre in native pasture, Nemaha County, Kansas.

Land type	Rating for native pasture	Estimated carrying capacity acres per animal unit/1	Estimated beef production per acre in native pasture/2
1	100	2.91	79
11	85	3.43	67
2	60	4.79	48
21	45	6.39	36
22	40	7.19	32
23	60	4.79	48
231	40	7.19	32
24	50	5.75	40
25	50	5.75	40
3	100	2.91	79
31	75	3.90	59
32	50	5.75	40
33	55	5.23	44
4-41	95	3.07	75
County average	72.6/3	4.00/4	58

[1]Under constant management equivalent to the management prevailing throughout the county over the period used as a base in estimating the county carrying capacity figure. Computed by using the long-time average carrying capacity with the productivity ratings.

[2]Computed from estimated carrying capacity using 230 pounds of beef as the average production per animal unit for the full grazing season.

[3]Weighted on the basis of the acreage of pasture in each land type.

[4]Average carrying capacity of native pastures in Nemaha County as estimated by a committee of Kansas Agricultural Experiment Station personnel as a part of the Production Adjustment Studies in Kansas, 1935.

For any given soil these ratings may, or may not, be the same.

In this study, the carrying capacity of a rotation of sweet clover and sudan grass, was considered to be one and one-third acres per animal unit for the grazing season or three times the average carrying capacity of native pasture. Sweet clover and sudan were selected as typical temporary pasture crops for the area, and the production on each soil was made proportional to the relative ratings of the land types for a rotation of this nature. As in the case of pasture and the other cultivated crops, the yields may be weighted by the area of the crop on each land type and averaged to give the figure which had been found to be a long-time yield for the county. This serves as a useful check of the calculations employed.

The ratings for temporary pasture, the carrying capacity and pounds of beef produced per acre are indicated in Table 7. It should be emphasized that the yield figures for temporary pasture are extremely limited. This method of handling the land is included to illustrate the possibilities in evaluating land types and not to provide a dependable working figure for temporary pasture production. Additional information in regard to the gains which could be expected from this land use should enable future investigators to include it as a major part of the evaluation. Yields in temporary pasture have not been compared to other cropland or to native pasture uses.

Table 7. Estimated rating for temporary pasture and production in pounds of beef per acre,/1 Nemaha County, Kansas.

Land type	Rating for temporary pasture/2	Estimated carrying capacity acres per animal unit/3	Estimated production in pounds beef per acre
1	90	1.11	207
11	82	1.21	190
2	68	1.48	155
21	32	3.07	75
22/4			
231	50	2.00	115
23	78	1.29	178
24	60	1.67	138
25	38	2.67	86
3	95	1.06	218
31/4			
32/4			
33/4			
4-41	92	1.08	213

[1]These figures should be taken as only a rough estimate owing to the incomplete information available concerning carrying capacity of temporary pastures.

[2]Average of ratings for sweet clover and sudan grass.

[3]Carrying capacity was determined in relation to an estimated average of 1.33 acres per animal unit. This is the figure used for area 4 in the adjustment studies conducted at the Kansas Agricultural Experiment Station.

[4]Not evaluated for crops because of its low productive capacity.

Conversion of Crop and Pasture Production to a Common Unit

For purposes of comparison, the corn equivalent produced by each land type in crops has been converted to the quantity of beef which could be produced by that quantity of corn. This permits a direct comparison with the pasture production values. One bushel of No. 2 yellow corn has been considered to be the equivalent of seven pounds of beef. This figure has been determined by feeding tests employing good quality steers, weighing between 400 and 1000 pounds.[31]

The same common denominator could be employed to convert the pasture production in terms of beef to a corn equivalent in terms of bushels of corn. In either case, the relationships would be the same. Pounds of beef have been employed in this study because the measurement of pasture productivity has been the dominant consideration and this is the most common measure of pasture production.

The total production of cropland in pounds of beef is shown by land types in Table 5.

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[31] Morrison, op. cit., p. 643.

Determination of Average Physical Productivity Ratings for Cropland

General physical productivity ratings may be defined as averages of individual physical crop productivity ratings. They do not represent the productive capacity of the land for any particular crop. For this reason, the general productivity rating of a soil may vary with changes in the cropping system.

General productivity ratings are useful in making comparisons on the basis of general agricultural value or in presenting material in graphic form. The index indicated for general productivity in this study is comparable to the index derived by methods which rate the soil for physical crop production in general. The Storie Index, discussed under productivity ratings, is a rating of this nature.

General physical productivity indexes for this study have been derived by averaging the individual productivity indexes for the crops grown in the rotation. Each index has been weighted by the frequency with which the crop has been grown. General physical productivity indexes, or ratings, for cropland are presented in Table 5. These general crop indexes have been employed throughout this paper for purposes of graphic presentation and comparison.

COMPARISONS BASED ON PHYSICAL PRODUCTIVITY

Relationship of Physical Product to the Productivity Ratings

Native Pasture. The productivity ratings for native pasture and the pounds of beef produced per acre in pasture are shown in Table 6. This same information is plotted in Fig. 1. The production on pasture has been calculated in direct proportion to the pasture rating and the physical productivity values fall along a straight line. The data show that the beef production per acre increases .8 pounds for every point the pasture rating increases. On average pasture, rating 72.6, the beef production is 58 pounds per acre. This would provide for 230 pounds of beef production per animal unit on four acres of average pasture.

Crops. The general productivity ratings for crops and the beef production in crops are shown in Table 5. The same information is plotted in Fig. 2. In this case, the physical productivity values do not fall directly on the line as was the case for pasture production. This is due to the fact that the crop production was calculated by using more than one crop. The absolute change in physical product did not bear the same relationship to a unit change in the productivity rating for one crop as it did for another. Two soils might have the same general productivity index but slightly

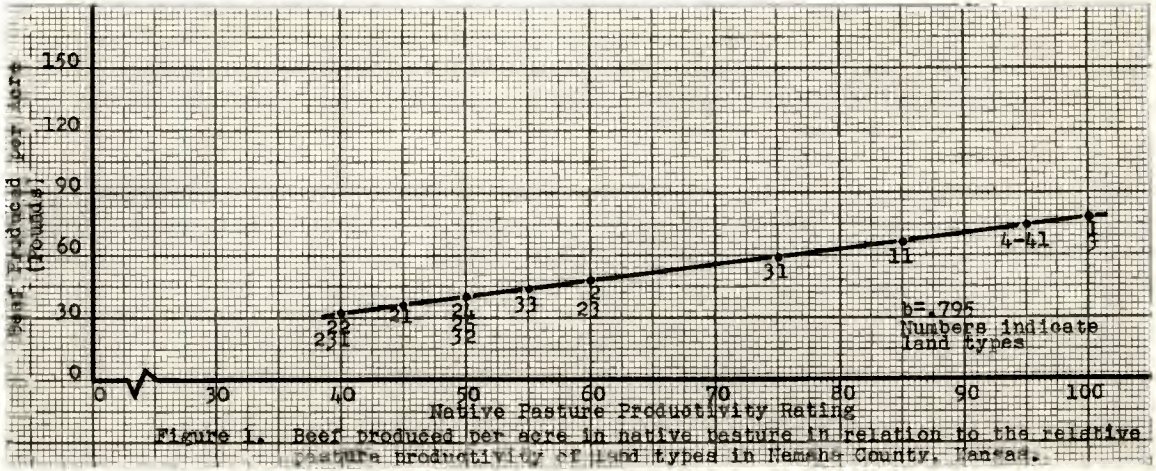

Figure 1. Beef produced per acre in native pasture in relation to the relative pasture productivity of land types in Nemaha County, Kansas.

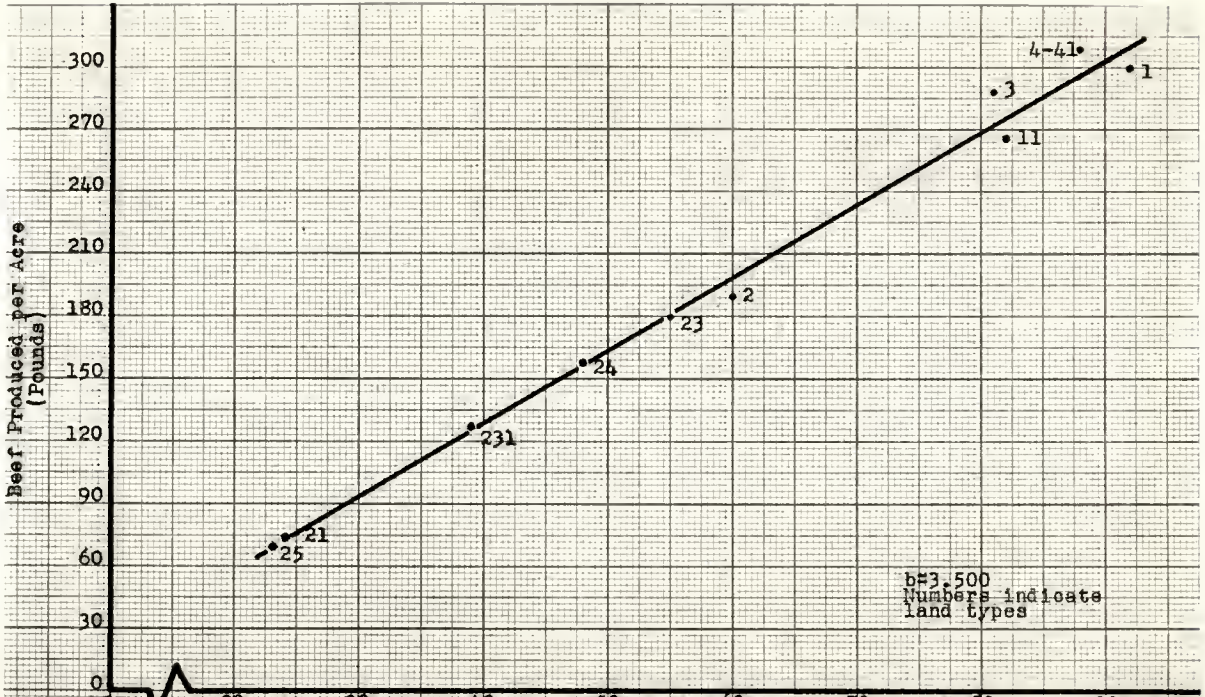

Figure 2. Beef produced per acre in cultivated crops in relation to the relative crop productivity of land types in Nemaha County, Kansas.

different physical production when the indexes are calculated in this manner. One of the average ratings may be high because of its rating for oats, a relatively low producing crop, while the other is high because of its high rating for alfalfa, a high yielding crop. This consideration should be kept in mind when making physical productivity comparisons by this method. If the physical productivities of two areas are to be compared, the crops used in the evaluation should be comparable in their capacity to yield feed units. Thus a comparison of a soil producing oats with one producing alfalfa probably would be worthless.

The regression line indicates that beef production per acre in crops increases 3.5 pounds for every point the crop rating increase. On the average cropland, rating 65, the beef production is 215 pounds per acre.

Temporary Pasture. The productivity ratings for temporary pasture and the estimated number of pounds of beef produced per acre are shown in Table 7. The same information is plotted in Fig. 3. The production of temporary pasture has been calculated in the same manner as native pasture and the physical productivity values fall along a straight line. The data show that the beef production per acre increases 2.3 pounds for every point the temporary pasture rating increases. The information on temporary pasture is limited and the values presented above should be considered as preliminary.

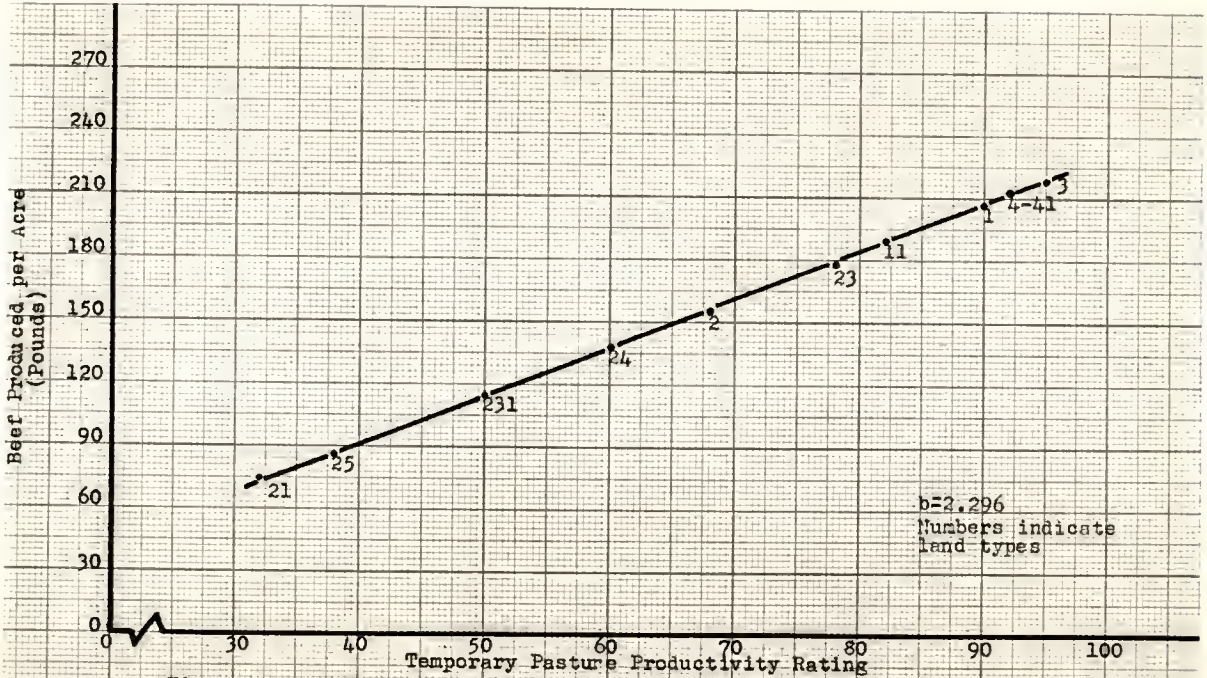

Figure 3. Beef produced per acre in temporary pasture in relation to the relative temporary pasture productivity of land types in Nemaha County, Kansas.

Variations in Productivity

General crop ratings, native pasture ratings and estimated beef production in crops or native pasture are shown by land types in Table 8.

The general crop ratings range from a high of 92 on Land Type 1 to a low of 23 on Land Type 25. This indicates that on a physical productivity basis, Land Type 1 will produce four times as much product as will Land Type 25. If productivity ratings were available for the extremely poor cropland classified as Land Types 22, 31, 32 and 33, this spread would be appreciably greater.

The pasture ratings range from a high of 100 on Land Types 1 and 3 to a low of 40 on Land Type 22. This spread is wide but is not extreme when compared to the range in crop productivity indicated above. The best soil when used for native pasture, will produce 2.5 times as much product as will the poorest soil in the county. It should be remembered that the least productive soils of the county have been rated for pasture and are included in this range.

This study has shown that land types are considerably more variable in terms of ability to produce cultivated crops than they are in terms of ability to produce native pasture. This variation is the result of the differing soil requirements of crops and pasture. While a deep, well drained, fertile soil

may be desirable in either land use, pasture is much less influenced by features such as slope, stoniness, erosion and similar characteristics. For this reason a soil may be relatively satisfactory for pasture production and fail to qualify as a crop soil.

Relation of Crop Production to Pasture Production

The average Nemaha County soil when utilized for native pasture, will produce 26.9 percent as many pounds of beef as when employed for a typical rotation of cultivated crops. Stated conversely, the average soil in the county, if used for crops, will produce 3.7 times as much beef (or corn equivalent) as when used for native pasture under the management practices prevailing in the area.

This information, together with the percentage relationships of pasture production to crop production for the individual land types, is shown in the righthand column of Table 8.

The physical production is greater for crops than for pasture on all soils for which ratings are available but the individual land types show marked variation when the production of pasture is compared to the production of cropland. The percentage relationships, as shown by the table, vary from 24.3 percent on Land Type 4-41 to 57.1 on Land Type 25. The better land types, as indicated by high crop and pasture productivity ratings show an appreciably greater spread between pasture and

Table 8. Relative rating and beef production per acre for cropland and native pasture and relationship of crop production to pasture production, Nemaha County, Kansas.

Land type	General crop rating	Native pasture rating	Estimated beef produced per acre		Percentage pasture production is of crop production
			Crops	Pasture	
1	92	100	300	79	26.3
11	82	85	266	67	25.2
2	60	60	190	48	25.3
21	24	45	74	36	48.6
22[1]		40		32	
23	55	60	180	48	27.0
231	39	40	127	32	25.2
24	48	50	158	40	25.3
25	23	50	70	40	57.1
3	81	100	288	79	27.4
31[1]		75		59	
32[1]		50		40	
33[1]		55		44	
4-41	88	92	309	79	24.3
County average	65	72.6	215	58	26.9

[1]Not evaluated for crops because of its low productive capacity.

crop productivity than do the poorer soils.

This relationship indicates that emphasis should be placed on cropland uses for the better soils as exemplified by Land Types 4-41 and 1, while pasture requirements might best be satisfied by employing the poorer soils as exemplified by Land Types 21 and 25 for grazing.

FUNDAMENTALS OF ECONOMIC PRODUCTIVITY STUDIES

Significance of Economic Productivity

Economic productivity refers to the economic rent which a given land type will produce under clearly defined systems of management. It is a measure of the income producing capacity of land, and as such, is of paramount importance in determining the land value. Tax assessors, farm credit agencies, farm managers and prospective purchasers attach major significance to economic returns. Other factors such as yields, total physical product, prices and costs are considered because they exert an influence upon this dominating factor of economic return.

Economic rent from a given piece of land may vary as the land use and management system changes. This variation is one of the primary factors responsible for the organization of agriculture as it exists today. Thus, the prevailing organization in Nemaha County has resulted from the efforts of

farmers and stockmen to adapt their resources to the physical and economic conditions which prevail. The economic rent from a specific area of land provides a yardstick by which the desirability of competing land uses or management systems may be measured.

This study was planned as a measure of both physical and economic productivity of land types when used for native pasture and for cultivated crops under prevailing farm conditions.

Physical yields were determined under these assumptions and are available as a basis upon which the economic rent to the several land types may be ascertained. The values for economic rent as determined in the economic productivity studies provide the most dependable evaluation of pasture and cropland productivity available for the area.

Factors Affecting Economic Productivity

Physical Productivity. The economic rent which may be expected from a given land type is determined by a number of factors. The most fundamental of these is the physical productivity of the land itself. The quantity and quality of product which will be available to pay expenses and provide a net return to the land is directly affected by the physical capabilities of the soil. In the preceding discussions, it has been emphasized that physical productivity alone does not provide sufficient information to determine the land use. It should be remembered, however, that before the economic rent

can be calculated, the physical response of the land to the various practices and treatments must be known. Physical information for use in this study has been provided by the productivity ratings and average yields for Nemaha County.

Prices and Costs. Prices received for the physical products and the relative costs incurred in producing them have an important bearing on economic rent or economic productivity. These factors must be considered along with the physical productivity and help to determine the net production of the land. Thus, the land use or management system which provides the greatest physical output may not be the most profitable in an economic sense. The added costs necessary to produce the last unit of product may be greater than the price which can be realized from its sale.

Prices and costs of labor, capital and materials are ordinarily considered as beyond the control of the individual land owner or farm operator. They exist as a result of the general economic order, of the demand and supply situation for the products and services considered. Economic rent is dependent upon these factors just as it is dependent upon the inherent physical capabilities of the land. As population numbers, consumer habits, availability of natural resources and related factors change, the relationships between prices and costs change and economic rent to land is affected correspondingly. In this study price and cost relationships which have existed in the past and which appear probable in the future, have been

employed in determining the economic rent to the land types for each of the land uses considered.

Management Systems and Quality of Management. The general nature and significance of management systems and quality of management have been discussed but their special economic implications should be mentioned. The economic rent from land varies with the land use and method of handling the land and its products. This is due, partly to the change in physical output, and partly to the fact that the changing management systems may involve greater or lesser costs. A change from livestock grazing to crop farming may involve a considerable increase in physical product and gross income but it will also involve an extensive change in production methods and costs. In this study, the information gathered in the area analysis study of Nemaha County has been employed together with any other available data in an attempt to determine the existing management system and quality of management. These estimates have been employed as a basis for determining the economic rents.

In other studies, having different goals or objectives, the management systems may be varied from farm to farm or may be applied at a different level of efficiency. In studies of this nature, the economic rent would vary when management systems or quality of management varied while inherent physical productivity, prices and costs would remain constant. The objective of such an approach would be to indicate the relative

profitability of the several organizations or methods under given conditions.

Location. The location, or geographic position, of land is important because of transportation costs. The effects of location may be felt in the form of higher or lower prices or as higher or lower marketing and transportation costs.

Because the location of land is fixed, the factor of location is felt by the landowner in the form of price modifications. In evaluating an area of land, the geographic position and such factors as kind and quality of roads must be considered.

For areas such as Nemaha County, the general economic productivity of land for farm uses is not materially influenced by location. The more remote sections are affected in the form of slightly higher marketing costs.

In this study, the factor of location has not been taken into consideration. The several land types are intermingled throughout the county. This study deals with land types as such and does not distinguish between an area of a given land type in one part of the county and another area of that same land type in a different portion of the county. If the information presented in this study is to be applied to a specific farm, the factor of location must be considered in the determination of its value.

Approaches to Economic Productivity Studies

Economic productivity may be determined in many ways. Any person who places a monetary value on an area of agricultural land has arrived at an economic productivity figure or its equivalent in terms of total value even though he may not approach the problem in this manner. Other factors, as amenity values and anticipated changes in land prices, may modify the evaluations based on economic productivity but seldom exert more than secondary influence.

Estimates of value may be based on anything from a superficial inspection of the farm lands and buildings to a thorough and detailed budgetary analysis of anticipated costs and expenses under prescribed economic conditions and management practices.

Most of the approaches may be classified under one of the two headings discussed below.

Direct Methods. The direct method may be referred to as the "budget" approach. This technique has been used widely in farm management work and has enjoyed some favor in farm credit and appraisal studies.

A budget is a proposed plan of organization and operation for the farm business. It contains a list of the items of income and expense which may be expected from a given land type of specified physical productivity when handled in a

designated manner under given economic conditions. When properly prepared, it presents a complete plan or picture of the business operations for the period under consideration and may be used to provide an estimated net return to the land after all charges for labor, capital and management have been deducted. A somewhat similar approach is available through the use of actual farm records or experiences.

This direct approach has several advantages. It is flexible. That is, it may be adapted to various land uses, prices or management systems. It provides a realistic measure of what may be expected under the conditions imposed.

If information on costs, practices, labor requirements and similar considerations is available, it may be employed with less field work than a study based on some of the indirect methods described below. The results of the analysis are clear cut and to the point. They do not have to be reworked or evaluated to indicate a direct monetary figure for economic rent.

The major objection to the budget approach has been based on the assumption that budgets are hypothetical and do not represent conditions which actually exist. This criticism is only partially justified. The major shortcoming of budget work lies, not in the nature of the budget itself, but in the nature of the standards which are available for the preparation of budgets. Budget standards provide prices, costs, production practices, labor requirements, feed requirements and related

information necessary to intelligently plan the organization and operation of the farm. They may be based on existing conditions or upon some arbitrary level of efficiency. In either case, the determination of budget standards is a major problem in itself and has not been considered as a direct objective of this study.

The budget standards employed have been obtained from two major sources. The first has been the preceding area analysis and land-use adjustment study in Nemaha County.[32] This study will hereafter be referred to as the "Nemaha County study". A considerable quantity of information pertaining to local conditions in the specific area was collected and used in the preparation of farm budgets at that time. The second major source of information has been the unpublished standards on production methods and operations employed by the Department of Agricultural Economics at the Kansas Agricultural Experiment Station. These standards are based on controlled experiments, field surveys and account book data representing hundreds of farms.

When the available information was not adequate for the purposes of the study, modifications were made or supplementary standards were derived. Additional information concerning costs and management practices would be of considerable value for purposes of supplementing or modifying present budget

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[32] Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." loc. cit.

standards.

A second objection to the budget method deals with the work necessary for the preparation of budgets to represent individual farms or land types. If adequate budget standards are available, the preparation of budgets for each land type under each major land use should not require an excessive amount of time. For purposes of individual farm unit appraisal, the budget provides one of the best indications of economic value.

Indirect Methods. The indirect methods for determining physical productivity are numerous and varied. The most common approach is provided by a visual inspection of the land and an interpretation of the visible characteristics as profile slope, growing crops, and farm buildings in terms of previous experience with similar land or similar farms. This approach is subjective and depends almost entirely upon the experience and judgment of the appraiser.

Several modifications of this method have been employed in determining general land classifications for broad agricultural areas. In these studies the number and condition of farm buildings, mortgage delinquency and similar factors have been related to the economic productivity of the land.

It is obvious that this approach does not indicate specific productivity for each land type as there may be several land types in the same farm. It is also true that such an appraisal considers only the general land use as observed and does not

evaluate specific land uses such as the employment of native pasture, temporary pasture, or cultivated crops.

APPLICATION OF THE METHOD

Partial Budgets

The direct approach has been selected for the conversion of inherent physical productivity to economic productivity under economic conditions and management systems existing in Nemaha County.

The budget methods ordinarily employed have been modified to fit the requirements of this study. Those income and cost items which have a direct bearing upon the economic rent have been retained and developed. Those portions of the conventional farm budget which do not bear directly upon the economic rent have been modified or eliminated. As an example, budgets for cropland include complete information on rotations, tillage practices, harvesting techniques, disposal of the products and the corresponding income and expense items. They do not include a livestock organization or the income and expense items connected with a livestock program.

This specific approach was adapted for several reasons. In a general farming area in which a varied rotation was common, no single crop or single enterprise would provide sufficient information to determine either the physical or

economic productivity under prevailing conditions. For this reason, a typical rotation was selected. The crops produced were evaluated at long-time average prices to determine the gross return from the land. This technique was used to eliminate the influences of management systems, location, price, cost and related factors which influence the profitability of livestock enterprises without exerting an appreciable effect upon the economic rent to the agricultural land itself. There has been no attempt to isolate crop production as the only enterprise on actual farms. This technique merely attempts to evaluate the feeds and grains produced by the land at their local exchange value without involving the complications of a complete crop and livestock budget. Fixed costs and labor or management charges on the typical farms have been apportioned to the cropland in keeping with the portion of the particular expense incurred in producing the crop.

Pasture evaluations in this study have included a livestock enterprise. This approach has been necessary because pasture must be harvested by livestock. In this case, the farm organization, of which the pasture was considered to be a part, has been assumed to include phases of production other than grazing. This is typical of Nemaha County farms. The costs and income evaluations as employed in the budgets have been determined with this consideration in mind.

It has been felt that the employment of this modification of the budget method would result in the most dependable

appraisal of economic crop and pastureland productivity possible with the physical data, budget standards and resources available for studies of this nature at this time.

Labor and Management Charges

The determination of an amount to charge for labor and management was the most difficult problem encountered in preparing the budgets.

The charge selected was 40 cents per hour of man labor employed. The number of hours needed to complete the several farm operations was determined by the budget standards. This value of 40 cents per hour has been employed in all budgets but constitutes an appreciably large portion of the total production costs for cropland than it does for native pasture.

The most serious weakness of an hourly wage charge lies in the fact that all labor performed in the varying farm tasks does not include the same portion of pay for management. The work performed for one enterprise, or for one operation within an enterprise, may be entirely labor and should be evaluated at no more than the average wage rate for hired labor of that level. Other tasks are made up primarily of management and involve a considerable amount of judgment and experience. These operations should be evaluated at a higher rate. Another approach would assess a definite fixed sum for management purposes and value the labor at the going rate of wages. This

is one of the best theoretical approaches but presents considerable difficulty when an attempt is made to determine the amount which should be used as a charge for management.

In this study, the charge for labor and the charge for management have not been separated. Both were included in the 40 cents per hour which was used as a labor charge in all budgets. This value for the farm operator's labor and management would provide a total income of $1200 per year for the farmer who spends 3,000 hours at productive labor on the farm.

The average net farm income for 802 annual records of 346 Kansas Farm Management Association farms for the years 1934 to 1940 has been $1727.[33] This figure includes interest on investment, family labor, and the value of farm products used in the home. When these factors have been deducted, the cash payment for operator's labor and management would approximate $1200.00 per year.

Lord and associates have used $1200.00 as the standard labor and management return for rural families in determining the value of land for assessment purposes in Montana.[34]

When more adequate standards become available, it may be possible to separate labor and management charges and thus obtain greater accuracy of detail in making evaluations of this nature.

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[33] Myrtle A. Gunselman, "Farm Income and Living Costs." Kansas Agricultural Experiment Station Bulletin No. 327. June, 1945.

[34] Lord, Voelker and Giesecker, op. cit.

Determination of Economic Productivity

General Approach. Each land type has been evaluated for use as cropland, native pasture and temporary pasture. The inherent differences in organization consistent with these three major land uses have necessitated a separate management system for each.

In all evaluations, the physical production has been multiplied by the long-time average price to determine gross return. All costs, including operating expenses, depreciation, interest on investment in working capital and buildings, labor, management and taxes on working capital and buildings have been deducted from the gross income to provide the net return or economic rent. This residual, the economic rent from the land, is the amount available for payment of land taxes, soil conservation costs and return to the landowner. The return to the owner when capitalized at the prevailing interest rate, becomes the primary determinant of agricultural land value.

The three management systems employed have been devised with the objective of making the costs, prices and management proficiency for the three major land uses as consistent as possible. This is an essential requirement of the method if results are to be comparable.

It is felt that the relationship between the various cost and income items is of major importance while the actual level

is of lesser significance. If costs and prices are approximately the same percentage above average, the net result is not likely to be seriously affected. The same condition applies to comparisons between the different land uses. If the relative prices for crop products are in line with the relative prices for pasture products, the relation between economic rents from cropland and pasture is not likely to be seriously distorted. Of course, the actual price level is of considerable importance in placing a specific dollar valuation upon land and it is desireble that the data employed reflect the specific level of prices and costs as well as the relative values.

The economic rent for any particular year probably will not be equal to the calculated value. This is due to the variation in yields and prices. Over a period of several years, the fluctuations will be averaged to the extent that the averages of the yearly economic rents for the period should approximate the value calculated using average price, cost and yield data.

Cropland. The gross return from each land type in crops was determined by employing the physical production found in the first section of this study with long-time average farm prices for the area. Marketing charges have not been included for the crops commonly consumed on the farm.

The specific practices followed have been based upon the budget standards for eastern Kansas as employed by the Kansas

Agricultural Experiment Station and upon the standards derived and utilized in the preceding Nemaha County study. They have been carefully appraised to determine their applicability to productivity studies of this nature. The charge for labor and management was 40 cents per hour. The charges for machinery cost and machinery investment per crop acre and related factors are based upon the standards employed in calculating farm budgets for the area analysis and adjustment study in Nemaha County. In some instances, these charges have been modified to more nearly comply with conditions which exist over the county or to better adapt the data to management systems or practices employed in the study.

The costs and charges have been held constant for each land type whenever experience would indicate that this situation actually exists. Thus, machinery investment per acre, taxes, interest rates and planting and cultivating expenses have been held constant for the several land types producing the same crops. Those charges which change with production, such as harvesting costs, have been varied in proportion to the yields but were never reduced below a specific fixed amount which represented the minimum charge necessary to harvest any of the crop. Additional information concerning the responses of crops to management systems and the physical costs of achieving these responses would enable the investigator to vary the practices or management systems on individual land types. This procedure is subject to the advantages and

limitations discussed under the heading "Management Syatems".

The machinery costs on farms producing sorghums in the rotation have not been considered to be the same as those on farms producing corn. This variation was the result of the differences in harvesting methods for corn and sorghums. In either case, the organizations have been developed to represent typical conditions in the areas producing these crops.

A cropland area of 160 acres was used for the determination of economic rent to land when employed for crop production. It represents a crop acreage somewhat larger than that which exists on the average Nemaha County farm but is appreciably smaller than the typical Farm Management Association farm in Type-of-Farming Area 4 of Kansas.[35] The importance of this factor is modified by the fact that the machinery investment, machinery cost, labor, fuel oil and related charges are furnished on a per-acre basis by the budget standards. It was felt that an area of 160 acres would enable the operator to utilize the machinery available and employ his time and management in an effective manner and that the resulting net income to the land would be in keeping with the net income which may be expected in this county as new and better methods and practices are developed and applied.

The building investment was established at $750 per farm.

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[35]Milton Manuel and Associates, "Kansas Farm Management Summary and Analysis." Kansas Agricultural Experiment Station Agricultural Economics Report No. 29. 1945.

These buildings represented shelter for the equipment and any grain, feed or supplies which might be charged to the crop enterprises. Their value was based on the $2500 building investment employed for complete farm budgets in the preceding Nemaha County study.

The investment in seed and supplies was estimated at $100.

The crop machinery investment has been $7.50 per crop acre. This value is based on a total machinery investment of $10.00 per crop acre. At long-time average farm prices of crop machinery, as shown by Fenton and Barger[36], this investment would be ample to supply the equipment necessary to carry out the crop production and harvesting operations as outlined below.

The total building and equipment investment for crop production when calculated in the preceding manner was $2050. This value was employed in each budget as the same equipment was required for efficient production irrespective of the land type.

Interest on the investment in buildings, supplies and equipment has been calculated at five percent. This charge represents a long-time average interest rate. It is probably low when considered in terms of interest rates on working capital but would be satisfactory when compared to rates on

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[36] F. C. Fenton and E. L. Barger, "The Cost of Using Farm Machinery." Kansas State College Engineering Experiment Station Bulletin No. 45. April, 1945.

real estate loans.

Taxes on investment in buildings, supplies and equipment were calculated at 0.75 percent. This is the rate which was determined and employed in the Nemaha County study.

Crop machinery repairs and depreciation were charged at the rate of $2.00 per acre for rotations producing corn and $2.50 per acre for rotations producing sorghums. The difference in charges was necessary to keep machinery expenses for the two land uses comparable. The sorghums were bound and threshed with a combine while corn was picked by hand. The charge is in keeping with standards employed in the Nemaha County study and with the charges as determined by Fenton and Berger.

Building depreciation and costs were considered in relation to similar costs as employed in the Nemaha study. The annual charge was $40.50 per farm unit.

A marketing charge of $0.12 per bushel of wheat has been made. Wheat prices as used in the study represented the Kansas City market and this charge covered hauling, freight, and middlemen's margins. No marketing charge has been deducted for handling the remaining grain or hay. The local market price has been employed in evaluating these products and the assumption has been that they would be fed on the farm. Any surplus could be sold or a deficiency could be made up at prevailing local prices.

The operations and specific practices employed in producing the crops have been based upon unpublished standards used

by the Kansas Agricultursl Experiment Station in Eastern Kanssa studies. They indicate the equipment needed, the number of hours of man or horse labor and the number of gallons of fuel and oil nocessary to complote the operations. In calculating the lsbor and fuel requiremonts, each land type has been handled in an identical manner except for the hsrvesting of certain crops. This approach was adapted because tho prevailing procedure hss been to farm the sovoral lsnd typos in much the same manner, particularly if they occur as portions of the same field. The harvesting chsrges have boon varied with changes in yields.

The manner in which thc corn crop was hsndled will illustrate tho method. The corn was plowed (2-14"), tandem disced (7-8'), listed (2 row), curled twice (2 row) and cultivated twice (2 row). These oporstions required 4.0 hours of man labor, 6.8 gallons of fuel and .130 gallons of oil. They were considered to bo constant for all land types. Avorage harvesting expenses for corn using s man and team were five hours man labor and 10 hours horse labor per scre. The hsrvesting chsrge would vary with tho yield of corn but would not fsll bolow the cost of covering the land whon harvesting a marginal crop. The harvesting charge, therefore, has boen related directly to the relstive rating of the particular land type for corn but has not been reduced below three hours of man labor and six hours of horse lsbor on any land typo, irrespectivo of yield.

Corn stover was evaluated in terms of estimated value of standing corn stalks as used in production adjustment studies at the Kansas Agricultural Experiment Station.

Wheat and oat lands have been prepared in the recommended manner and the crops have been harvested with a combine. In this case, harvesting expenses were not varied. A complete coverage of the land was necessary in any event and the saving in time and expense when harvesting lower yields was not considered sufficient to merit an adjustment.

Sorghums were produced in the same manner as corn but were bound, shocked and threshed from the shock with the combine. Harvesting charges were variable.

Alfalfa, as handled in the rotation, was plowed up after four years and as a result one fourth of the alfalfa land was considered to be newly seeded each year. Seeding rates and expenses were determined according to the standards. Harvesting costs were based on three cuttings and were varied to allow for the additional expenses incurred in hauling and stacking the higher yields.

The sorghum stover was evaluated in terms of estimated feed value as used in production adjustment studies conducted at the Kansas Agricultural Experiment Station.

Wheat pasture was valued at $1.12 per acre on average wheat land. This value represents a typical use system and does not indicate the maximum yields which could be obtained if this resource were utilized fully.

In all budgets, a miscellaneous charge of 25 percent of total calculated labor costs was made for man and horse labor. A similar charge of 10 percent was made for fuel and oil.

Miscellaneous crop expense for the farm unit was considered to be $50.

The long time average prices and values for commodities produced or purchased as determined for the Nemaha study were employed in determining the economic rent to the several land types. The prices employed are shown in Table 9. These prices are representative of local conditions and should indicate the exchange value of the several farm commodities on the farm.

The list of income and expense items and the resulting economic rent in crops is shown for Land Type 2 in Table 10. A crop budget and similar summary has been calculated for each land type in crops.

The total gross income and total production expenses (with the exception of land charges and land tax) as discussed above are shown for each land type in Table 11. The same information is plotted against the general crop rating in Fig. 4.

The gross income, as calculated by the budget method described, increased 22.4 cents per acre for each point of increase in the general crop rating. Gross income varied from $4.63 per acre on Land Type 25 to $19.91 on Land Type 1. The three land types upon which a rotation including sorghums was used (231, 24 and 3) show slightly greater income than the land types of similar general crop ratings upon which corn was

produced. This is the result of the more intensive utilization of the sorghum stover and indicates the effect of changing management systems on physical product and gross income.

Table 9. Estimated prices employed in the preparation of budgets./1

Commodity	Unit	Price
Wheat/2	Bu.	$0.85
Corn	"	0.60
Sorghum grain	"	0.55
Alfalfa	Ton	8.00
Oats	Bu.	0.35
Corn stover (standing stalks)	Ton	1.00
Sorghum stover (bound)	"	2.00
Wheat pasture	Acre	1.12
Steers (good to choice, average of April and September price)/2	Cwt.	7.84
Steers (good to choice, April price)/2	"	8.16
Salt	Pound	0.03
Man labor	Hour	0.40
Horse labor	"	0.08
Fuel	Gallon	0.10
Oil	"	0.60
Twine	Pound	0.10
Alfalfa seed	"	0.14
Corn seed	Bu.	2.00
Sorghum seed	"	2.00
Marketing charge for livestock	Cwt.	0.50
Marketing wheat	Bu.	0.12

[1]From W. H. Pine, "Area Analysis and Agricultural Adjustments in Nemaha County, Kansas." Kansas Agricultural Experiment Station Bulletin No. 305. October, 1942. Estimated in consultation with the Marketing Staff of the Kansas Agricultural Experiment Station. Long-time averages were used as the basis for the prices. Unless indicated, all prices are at local markets or on the farm.

[2]Kansas City price.

Table 10. Calculation of gross income, expenses and economic rent for crops on Land Type 2.

Item	Amount	
Receipts:		
Corn	$676.80	
Wheat	587.20	
Oats	166.60	
Alfalfa	499.20	
Corn stover	103.20	
Wheat pasture	45.00	
Gross income		$2,028.00
Expenses:		
Marketing wheat	$ 75.84	
Seed purchased	40.00	
Fuel and oil	115.19	
Machinery repairs and depreciation	320.00	
Man labor	508.40	
Taxes	15.37	
Interest	102.50	
Miscellaneous crop expense	50.00	
Building depreciation and costs	40.50	
Horse labor charge	60.56	
Total expense		1,328.36
Economic rent to farm (Receipts - Expenses)		$ 699.64
Economic rent per acre		4.37

Table 11. Crop rating, gross income, expenses and calculated economic rent for a representative system of cropping, Nemaha County, Kansas.

Land type	General crop rating	Estimated gross income per acre/1	Estimated expenses per acre/1	Estimated economic rent per acre/2
1	92	19.91	9.59	10.32
11	82	17.64	9.18	8.46
2	60	12.67	8.30	4.37
21	24	4.93	7.35	-2.42
22/3				
23	55	11.63	8.21	3.42
231	39	8.68	8.40	.28
24	48	10.69	8.75	1.94
25	23	4.65	7.32	-2.69
3	81	18.52	10.15	8.37
31/3				
32/3				
33/3				
4-41	88	19.37	9.69	9.68
County average	65	14.20	8.90	5.30

[1]As determined by the budgets for cropland uses.

[2]Estimated gross income per acre minus estimated expenses per acre.

[3]Not rated for crops because of its low productive capacity.

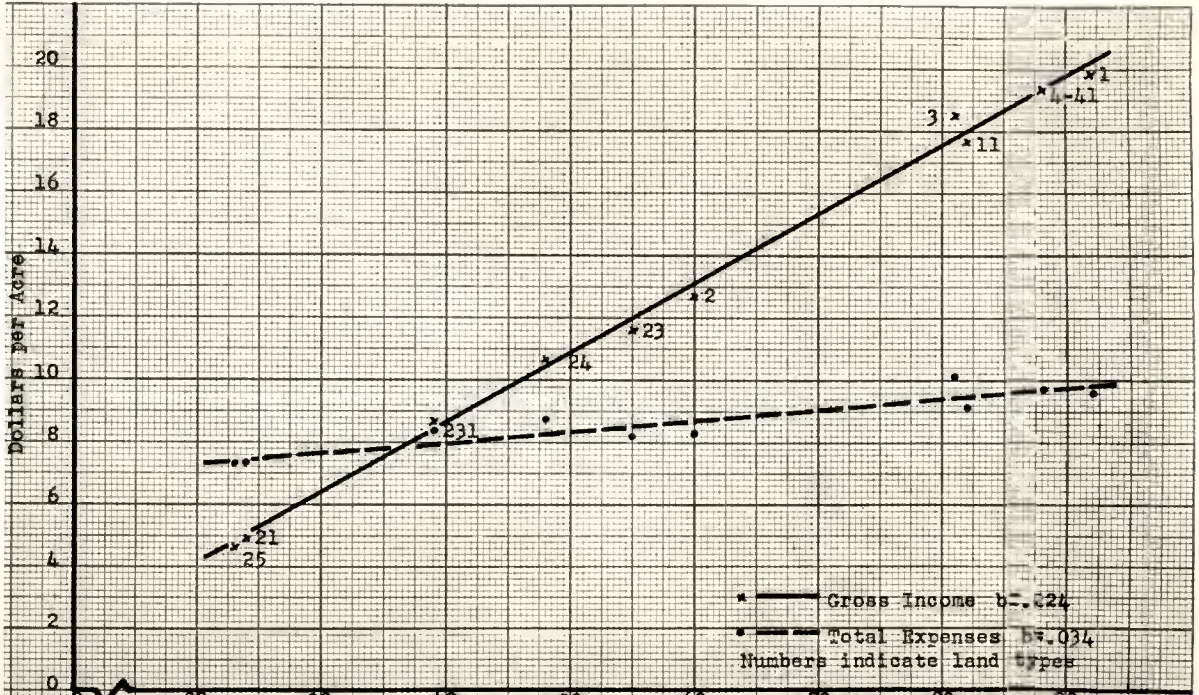

Figure 4. Gross income and total expenses per acre in cultivated crops in relation to the relative crop productivity of land types in Nemaha County, Kansas.

The total expenses as calculated by the budget method increase 3.4 cents per acre for each point of increase in the general crop rating. The lowest expense was shown by Land Type 25 and the highest expense by Land Type 3. If the relationship shown by the regression line is applied throughout the range of crop productivity, the expenses incurred would never fell below $6.95 per acre irrespective of yields. This is the result of the fixed charges necessary to produce any quantity of crop products under the management conditions existing in the county. The three land types (231, 24 and 3) showing the relatively high gross income, also show a relatively high production cost. This added expense is the result of the methods employed in cutting, shocking, and threshing the sorghums as compared to the husking charge on corn land of comparable general crop productivity.

The regression line for estimated expense crosses the regression line for estimated gross income at a physical crop productivity rating of 37. This indicates that crop production under Nemaha County conditions is not profitable on soils bearing a general crop rating below 37.

The general crop productivity and the economic rent per acre is plotted by land types in Fig. 5.

Native Pasture. Season long grazing with yearling steers has been employed as a management system for utilizing native pasture. The pasture has been charged with the value of the steers at the market price upon entering the pasture and has

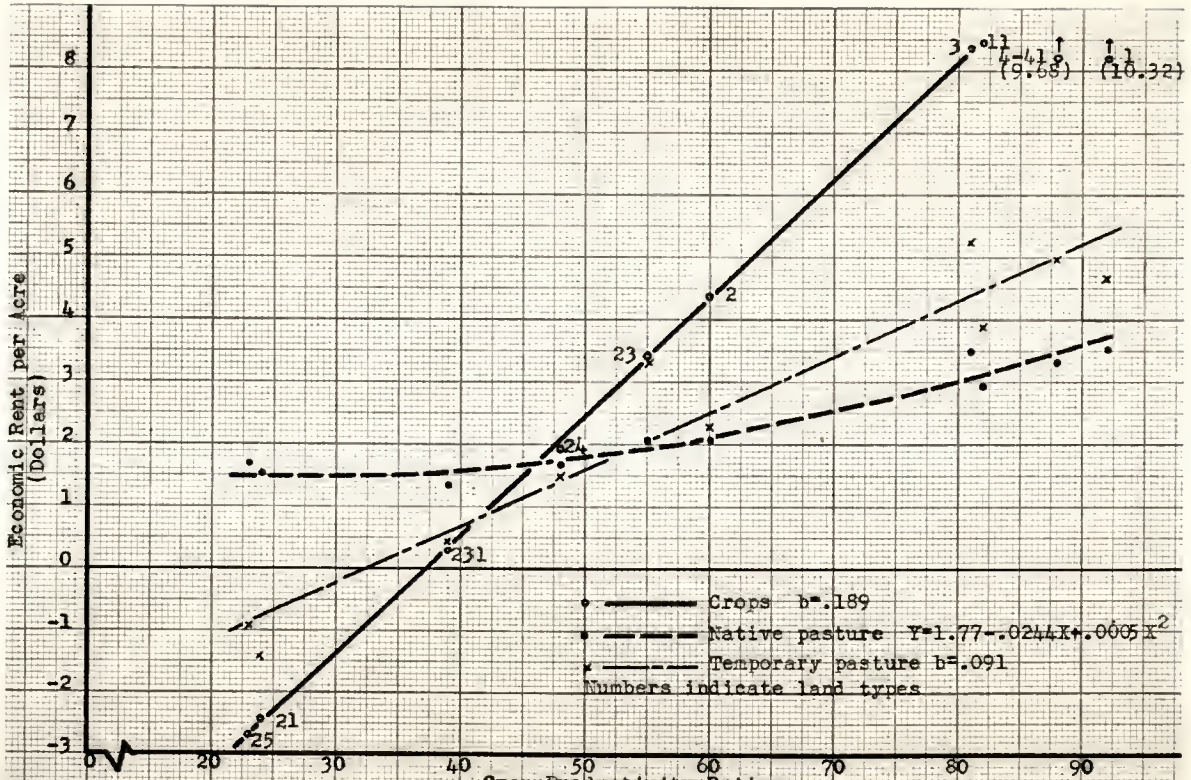

Figure 5. Economic rent per acre in crops, native pasture and temporary pasture in relation to the relative crop productivity of land types in Nemaha County, Kansas.

been credited with the estimated farm value upon leaving the pasture. This estimated farm value has been somewhat higher than the fall market price for stocker steers. If steers are purchased at the beginning of the grazing period and sold at the end of the period, they must be charged with all of the price decline as they are not retained in the business and any price fluctuations must be carried by pasture alone. Under farm conditions, the animals employed in the grazing program are normally utilized in other phases of beef production on the same farm. When they are handled in this manner, the seasonal price decline is not of comparable importance. The estimated value of steers upon leaving the pasture has been taken to be the average of the spring and fall market prices.

Costs for pasture production are based upon the experience of ranchers as determined in the Nemaha County study and in an extensive study of beef cattle production methods in Chase and Lyon Counties.[37] The charge for fences and labor is borne by the pasture land but, as in the case of cropland, the land tax must be deducted from the economic rent as determined.

A pasture unit of 100 acres has been employed in this study. This acreage is somewhat larger than the pasture acreage on the average farm but like the crop acreage, is less than that of the typical Farm Management Association farm. For purposes of determining the economic rent in pastures, the actual size of unit selected is of minor significance so long

[37] Doll, Koenen, Hodges and Pine, loc. cit.

as the standards representing the labor, feed consumption and other costs are made per steer or per acre and are average or representative figures typical of the region.

The investment in livestock was varied directly with the number of steers which the pasture was considered capable of supporting. In each case, the purchase price was used and the weight of the animals was considered to be 500 pounds as they were placed on pasture

The investment in fences and that portion of the investment in watering facilities and equipment which has been charged to pasture totaled $150 and was held constant for all land types. Charges for interest, depreciation, and taxes on these facilities also were held constant.

All other charges, labor, marketing, interest on steers, tax on steers, and similar considerations have been varied directly with the number of animals. The pasture has been charged with one-half the yearly interest on investment in steers and one-half the yearly tax. This allocation is justified on the assumption that the steers will be grazed one-half the year that they also will be utilized in other phases of the livestock program on the typical Nemaha County farm.

A marketing charge of $0.50 per 100 pounds has been charged against one-half the weight of the steers upon entering the pasture and against all of the gain in weight while upon pasture (230#). This is considered to be the marketing charge proportional to the contribution of the pasture to the animal as eventually marketed.

Two and one-half hours of man and horse labor have been allotted for each animal. The labor required per steer in this particular phase of the beef production program normally would vary as the size of the herd varied. The larger herds might be handled for a lower labor cost while smaller herds would require slightly more labor per steer. Since labor charges have comprised a minor part of total production costs, changes in labor requirements were not considered sufficiently important to include in the calculations. The labor charge indicated, does not include labor in maintaining fences. This is shown as a portion of the miscellaneous charge.

Death loss has been charged at the rate of one-half of one percent for the grazing season. The only supplemental feed has been 10 pounds of salt per animal.

If the investigator so desired, the income and costs for all factors except a portion of the fencing and fixed equipment might be determined on a per steer basis and this value could be used, within limits, in preparing economic evaluations of pasture lands. If the size of unit or handling methods changed appreciably, the charge per steer would have to be modified to fit the new conditions.

A complete budget was prepared for a 100-acre pasture of average productivity in Nemaha County. The summary of income and expense is shown in Table 12. This summary was employed as a master budget. The income and variable expense items for the individual land types were determined in accordance

with their relative carrying capacity. Variable expenses together with fixed expenses were then deducted from the gross income as calculated to determine the economic rent for individual land types.

The return per steer before fixed charges were deducted was $10.68. Fixed expenses on average Nemaha County soil, capable of supporting 25 animals per 100-acre pasture, total 60 cents per steer. On less productive soils, capable of supporting a smaller number of animals per 100 acres, the fixed costs per steer would be proportionately higher.

The net return per steer on average Nemaha County pasture was $10.08.

The native pasture rating and estimated economic rent per acre in native pasture are shown by land types in Table 13. The same information is plotted in Fig. 6.

Temporary Pasture. Alternate sweet clover and sudan have been employed as temporary pasture crops. The costs have been determined according to the budget standards for eastern Kansas and Nemaha County. Fencing charges, seed and seeding expenses have been considered along with the regular pasture charges as determined for native pasture in calculating total costs for temporary pasture uses. Gross income has been determined by using the physical production indicated in this study with the cattle prices as used in native pasture budgets. The land type ratings and anticipated economic rent in temporary pasture are shown in Table 14. The same information is

plotted against the temporary pasture productivity ratings in Fig. 7. It should be remembered that carrying capacity figures for temporary pasture are limited and that this information must be considered as preliminary.

Table 12. Gross income, fixed and variable expense and economic rent per acre and per steer on average Nemaha County soil.

Item		Amount	
Income:			
Livestock sales			$1,430.79
Expenses:			
Variable expenses:			
Livestock purchases	$1,020.00		
Salt	7.50		
Horse labor	5.00		
Man labor	25.00		
Tax on livestock	3.83		
Marketing cost	60.00		
Miscellaneous	16.90		
Interest on livestock	25.50		
Total variable expenses		$1,163.73	
Fixed expense		15.00	
Total expenses			1,178.73
Net economic rent			$ 252.06
Economic rent per acre			2.52
Net economic rent per steer			10.08

Table 13. Pasture rating and estimated economic rent per acre in native pasture. Nemaha County, Kansas.

Land type	Rating for native pasture	Estimated economic rent per acre in native pasture[1]
1	100	3.52
11	85	2.96
2	60	2.08
21	45	1.52
22	40	1.34
23	60	2.08
231	40	1.34
24	50	1.70
25	50	1.70
3	100	3.52
31	75	2.59
32	50	1.70
33	55	1.89
4-41	92	3.33
County average	72.6	2.52

[1]As determined by the native pasture budgets.

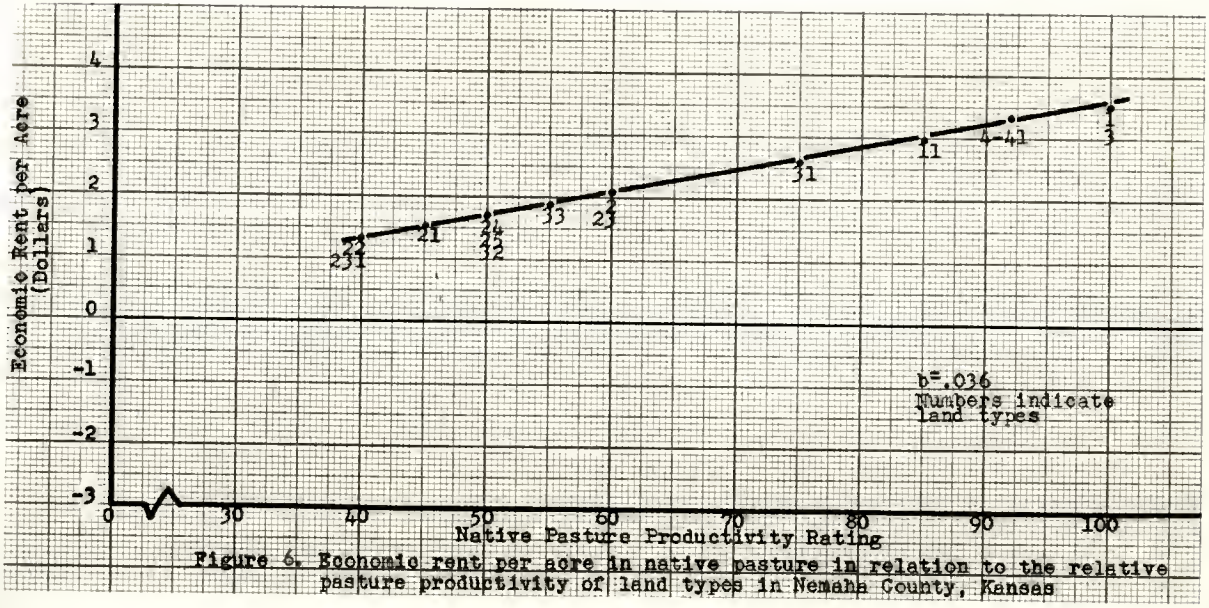

Figure 6. Economic rent per acre in native pasture in relation to the relative pasture productivity of land types in Nemaha County, Kansas

Table 14. Temporary pasture rating and estimated economic rent per acre in temporary pasture, Nemaha County, Kansas.

Land type	Rating for temporary pasture	Estimated economic rent per acre in temporary pasture/1
1	90	4.68
11	82	3.88
2	68	2.28
21	32	-1.44
22/2		
231	50	.42
23	78	3.35
24	60	1.48
31/2		
32/2		
33/2		
25	38	- .92
3	95	5.21
4-41	92	4.95

[1]As determined by temporary pasture budgets. These figures should be taken as only rough estimates. Available information concerning carrying capacity of temporary pastures is limited. Gains, prices and costs for the steers utilizing the temporary pasture were considered equal to those on native pasture. The cost of preparing the land and seeding the sweet clover and sudan has been deducted in each case.

[2]Not rated for crops because of its low productive capacity.

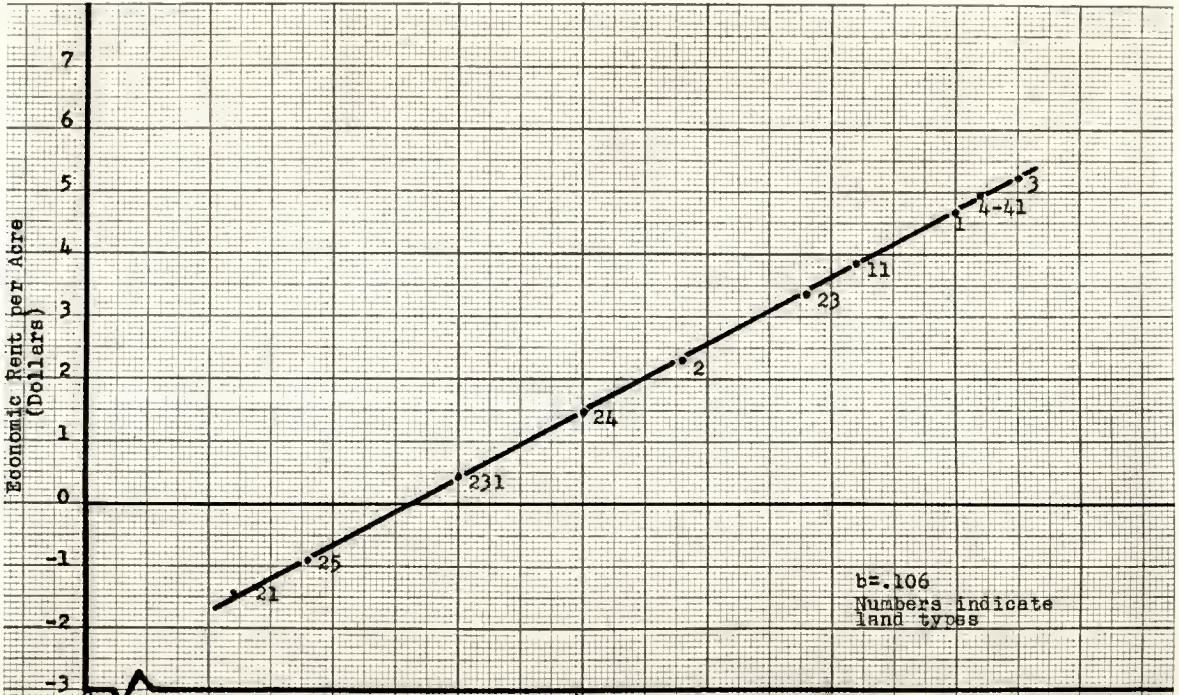

Figure 7. Economic rent per acre in temporary pasture in relation to the relative temporary pasture productivity of land types in Nemaha County, Kansas.

EVALUATIONS AND COMPARISONS BASED ON ECONOMIC PRODUCTIVITY

Relationship of Economic Rent to the Physical Productivity Ratings

The estimated economic rents obtained from the individual land types for each land use have been plotted against the physical productivity ratings for the respective land uses.

Cropland. The physical productivity ratings for crops and the economic rent per acre in crops are shown by land types in Table 15. This information is plotted in Fig. 5. The economic rent per acre in crops under management systems employed in the study increases 18.9 cents for every point the crop rating increases. The average soil of Nemaha County, bearing a general crop rating of 65, will produce an economic rent of $5.30 per acre. The regression line of economic rent on crop productivity crosses the zero economic rent line at a crop rating of 37. This rating corresponds to the point at which total expenses for crop production are equal to total gross income from crops and indicates that crop production is not profitable even upon tax free land below a general crop rating of 37 as assigned in the physical productivity evaluations in Nemaha County.

The economic rent values for the individual land types follow the regression line closely. Those land types upon

which sorghums were produced show higher gross income but have correspondingly higher total cost. The net result is an economic rent value in keeping with that calculated for land types of comparable productivity ratings which were used in the production of corn in the rotation. This relationship of gross income and costs as the intensity of the management systems is varied, is of considerable significance in selecting a method by which productivity may be measured. It indicates that economic rent, which includes variations in expenses, has shown less variation from the regression line that have the values indicating physical production or gross income alone. It also indicates that minor adjustments in the management systems may be included without materially changing the comparative position of the soils. This is of considerable importance when the land types being compared normally are handled differently and the investigator wishes to adapt his budgets to actual conditions and still compare the final results.

In actual practice, the combination of resources and the lines of production are determined by economic productivity as based upon prices, costs and the inherent physical capacity of the land. The physical production forms a basis for economic evaluations.

When the relationship between economic productivity and physical productivity has been established, the physical productivity rating may be employed as an index of economic productivity according to the relationship which has been shown

Table 15. Crop rating and estimated economic rent in crops, in native pasture and in temporary pasture, Nemaha County, Kansas.

Land type	General crop rating	Estimated economic rent		
		Crops	Native pasture	Temporary pasture
1	92	10.32	3.52	4.68
11	82	8.46	2.96	3.88
2	60	4.37	2.08	2.28
21	24	-2.42	1.52	-1.44
22[1]			1.34	
23	55	3.42	2.08	3.35
231	39	.28	1.34	.42
24	48	1.94	1.70	1.48
25	23	-2.69	1.70	- .92
3	81	8.37	3.52	5.21
31[1]			2.59	
32[1]			1.70	
33[1]			1.89	
4-41	88	9.68	3.33	4.95
Weighted county average	65	5.30	2.52	--

[1] Not evaluated for crops because of its low productive capacity.

to exist. With this consideration in mind, the statements concerning the comparative profitability of certain land uses may be expressed in terms of physical productivity ratings.

Native Pasture. The productivity ratings for native pasture and the economic rent per acre are shown by land types in Table 13. This information is plotted in Fig. 6. The economic rent from land in pasture increases 3.6 cents for every point the physical pasture productivity rating increases. The economic returns are directly proportional to the native pasture rating and fall along a straight line. Pasture of average productivity returns an economic rent of $2.52 per acre under the management employed. The extended regression line crosses the zero economic rent line at a rating of four. The carrying capacity of native pasture with this rating is so low that the net production of the steers is absorbed by overhead costs.

Temporary Pasture. The productivity ratings and economic rents for each land type in temporary pasture are shown in Table 14. The same information is plotted in Fig. 7. Economic rent in temporary pasture increases 10.6 cents for every point the temporary pasture rating increases. The regression line crosses the zero economic rent line at a rating of 46. At this point, the net return from the steers is absorbed by the overhead cost of preparing the seedbed, planting and caring for the temporary pasture crops and in fencing the area.

Additional information bearing upon the question of carrying capacity of temporary pastures may result in a different

point of intersection but the slope of the regression line should not be changed materially.

Relationship of Economic Rent from Native and Temporary Pasture to the Physical Productivity Ratings for Cropland

General crop productivity ratings and economic rents from crops, native pasture and temporary pasture are shown by land types in Table 15. The economic rents for the three land uses are plotted against the physical crop rating in Fig. 5. The economic rent values and the regression lines for native and temporary pasture on this graph differ from those discussed previously in that they are now plotted against the rating of the respective land types for cultivated crops rather than against the rating for native pasture and temporary pasture respectively. The individual values no longer fall along a straight line. This results from the fact that the crop rating, native pasture rating and temporary pasture rating for a given land type may not be the same.

The economic rent values for native pasture range from a high of $3.52 on Land Types 1 and 3 to a low of $1.34 on Land Types 22 and 231. The distribution of these values for native pasture indicates a distinct tendency toward curvilinearity. Along the upper ranges of cropland productivity, the pasture productivity tends to drop rather sharply as crop productivity diminishes. As the point of average cropland productivity (65)

is reaches, the pasture values show an increasing tendency to level off and remain constant irrespective of the crop rating. This relationship is farther substantiated by the fact that the four land types (22, 31, 32 and 33) which were considered too low in productivity to merit a crop rating show economic rents in native pasture ranging from $1.34 on Land Type 22 to $2.59 on Land Type 31. The second degree parabola fitted to the native pasture productivity data bears the equation $Y = 1.77 - .0244X + .0005X^2$, where Y is the economic unit per acre and X is the crop productivity rating. The fact that the economic rents from pasture do not change in proportion to the economic rents from crops as the crop productivity changes, substantiates the need for a separate pasture productivity rating by which the pasture may be appraised.

The economic rents for temporary pasture range from $5.21 on Land Type 3 to a loss of $1.44 on Land Type 21. The temporary pasture productivity values are more variable when plotted in this manner than are those for cropland or native pasture. They fall between the latter two with an increase in economic rent from temporary pasture of 9.1 cents for every point the crop rating increases.

Relation of Economic Rent from Native Pasture to Economic Rent from Cropland

The average Nemaha County soil, before land taxes have been deducted, will return an economic rent of $5.30 per acre in

crops and $2.52 per acre in native pasture. These values indicate that under the management systems, yields and prices employed in the study, average land when used for crops will produce slightly more than twice as much economic rent per acre as it will produce when used for native pasture. This relationship may be compared to the ratio of four to one for physical productivity. Since economic productivity appraisals are sought in evaluating agricultural land, the ratio of two to one would seem to provide a more realistic answer than the comparison based on physical productivity alone.

Individual land types as shown in Table 15, present a wide range of economic productivity. Land Type 1 shows the greatest advantage for cropland with an economic rent of $10.32 in crops as compared to an economic rent of $3.52 in native pasture. Land Type 25 shows the greatest advantage for pasture with an economic rent in pasture of $1.70 and a net loss of $2.69 per acre in crops.

Each individual land type as such should be considered in terms of the specific evaluations given in Table 15. The general relationships between pasture productivity and crop productivity of the several soils in the county may be presented effectively in graphical form as shown in Fig. 5. This graph together with Figs. 6 and 7 may be employed in the evaluation of land types in other areas of similar general physical productivity and type of farming.

The regression line for native pasture crosses the

regression line for crops at a crop rating of 46. This indicates that under Nemaha County conditions, any land type rated higher than 46 for physical crop productivity can be utilized most profitably for crop production while any land type rating less than 46 can be utilized most profitably in native pasture. This does not necessarily mean that all land rating less than 46 should be in native pasture. Such an arrangement might not be feasible under the type of farming common in the area nor would it always be desirable. The information does indicate that the tendency should be to utilize those land types, (21, 231 and 25) insofar as possible, for pasture purposes. It also indicates that the assessor or appraiser who wishes to determine the value of the farm under the most productive land use should consider the value as indicated in the pasture budgets. As the crop rating decreases, the desirability of pasture uses becomes increasingly apparent. Below a rating of 37, the crop uses do not pay for production costs. Any feed or grain needed can be purchased at less cost than it can be produced. With this consideration in mind, it would appear that Land Types 21 and 25 should be utilized entirely for pasture.

The tentative economic rents from temporary pasture are exceeded either by the cropland or by the native pasture values for every land type rated in Nemaha County. For this reason, temporary pasture does not appear to be the most desirable land use at any level of productivity, although the differences

in returns on Land Type 24 are not great.

The temporary pasture regression line crosses the native pasture regression line at a crop productivity rating of 53. This intersection point indicates that any pasturage needed on land types with crop productivity ratings above this point could be most profitably furnished in the form of temporary pasture rather than native pasture.

The fact that land taxes have not been included as production costs should be kept in mind. If taxes are considered as production costs, the economic rent values will be correspondingly modified. For purposes of assessment, productivity ratings of this nature may be used to determine the agricultural value of the land and the charge for taxes would be proportional to the economic rent as calculated. If the studies are being employed to evaluate a land area for purchase or credit appraisal, the existing tax rate must be considered as a fixed cost.

Charges for soil erosion or depletion have not been included in the budgets. Losses of this nature and the cost of any program to alleviate or prevent their occurrence must be considered in evaluating a land type. Bottom lands or other level soils, if handled according to the rotations employed, would present little difficulty in this respect. The value of soils having features which make them susceptible to erosion may be modified by this consideration.

Information concerning the monetary costs of the necessary

conservation practices by land types is limited. The problem is further complicated by the fact that the common measures of erosion control appear to have a favorable effect upon crop yields. They not only hold and preserve the soil but may actually improve yields enough to cover any increased costs.

The productivity ratings assigned in the study were made under prevailing management systems and did not apply to the soils under intensive conservation practices. The lack of information and the considerations mentioned in the paragraph above have prevented any modification of the returns to land types on this basis. The assumption has been that any recommended conservation practice necessary to preserve the soils in their present state of fertility will pay the costs incurred in its employment.

Comparison with Census Values

The weighted average economic rent in crops and pasture when reduced by the average rate of land taxation and capitalized at the average interest rate for the past 30 years indicates an average land value of $68 per acre in Nemaha County.[38] The average valuation of all land in farms for the Census years 1910, 1920, 1930 and 1940 was $69.

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[38] The average interest rate was estimated to be 5.5 percent. Based on information presented in "Agricultural Finance Review". United States Department of Agriculture, Bureau of Agricultural Economics. November, 1946. p. 97.

SUMMARY AND CONCLUSIONS

Economic evaluations of specific land uses as applied to individual land types may be employed by tax assessors in establishing a benchmark or normal value for the appraisal of individual farm holdings. They may be of assistance to the credit agency or prospective purchaser who wishes to establish a normal agricultural value for an acre of land under prescribed conditions. Finally, they should be of considerable value to the farm manager who would utilize his resources in such a manner as to maximize the net return from the land.

The objective of this study has been to develop a method for determining the productivity of pastures in relation to cropland. Physical productivities and comparisons have been employed, along with economic factors, in arriving at an economic evaluation of land types under prevailing management systems in Nemaha County, Kansas.

Information concerning physical production is a prerequisite of this type of economic productivity study. Physical productivity ratings for crops and native pasture were used with long-time average yields to determine the physical yields and carrying capacities which may be expected from each land type under the farm organizations and practices prevailing in Nemaha County. The yields from the several crops

employed in the rotation were averaged and converted to pounds of beef produced per acre. Total physical production in crops was then compared to total physical production in native pasture by land types.

The average Nemaha County acil, in native pasture, will produce 26.9 percent as many pounds of beef per acre as it would produce when utilized for crops. Crop production exceeds pasture production on all land types compared, but the relative advantage of crops is greater on the more productive soils and diminishes as the crop productivity rating diminishes. Crop production is more variable and presents a wider range of values than does paature production on the same land types.

Physical yields and carrying capacities, as determined, were used with long-time average prices and costs under representative management systems to determine the economic productivity for each major land use on each land type. A modification of the conventional budget technique was employed in the use of partial budgets covering only that portion of the farm income and expense which was concerned directly with the crop or pasture use in question. Kansas Agricultural Experiment Station standards and information developed for the budget studies in Nemaha County were adapted or modified to fit the requirements of the partial budget method. With the exception of harvesting expenses and variable costs, all land types were handled in a similar manner. Two rotations were employed for land in crops and one method was used as typical

of native pasture utilization.

Economic rent per acre was determined for each land type when used for cultivated crops, native pasture and temporary pasture under Nemaha County conditions. The values for temporary pasture are considered to be preliminary and most of the comparisons are made between crops and native pasture.

The average Nemaha County soil will return $5.30 per acre when used for cultivated crops and $2.52 per acre when utilized for native pasture. Economic productivity in crops increases 18.9 cents for each point the physical crop productivity rating increases. Land types bearing a crop rating less than 37 cannot be employed profitably for crop production under the management systems and cost relationships employed in the study.

Economic rent from native pasture uses is less variable than economic rent from cultivated crops. Pasture productivity increases 3.6 cents for each point the physical pasture productivity rating increases. It appears to be closely related to crop productivity on the better soils but tends to level off and remain constant as the crop productivity falls below average for the area. Economic rent in pasture is equal to economic rent in cultivated crops at a crop rating of 46. Any soil bearing a crop rating less than this may be used more profitably for native pasture than for crops.

Specific returns from the major land uses may be ascertained for any Nemaha County land type by reference to the

economic rent figures as calculated in the partial budgets. Information for other land types of similar general adaptability when handled in the same manner, may be determined from the regression lines which were calculated for this study.

Additional information concerning physical productivity and budget standards would be of considerable assistance in developing an approach of this nature. An accurate soil map, indicating those divisions of the soil having economic importance, is the first requirement of the method. The second requirement is a dependable set of productivity ratings for native pasture and for cropland under clearly defined management systems and quality of management. Data concerning actual yields are of value in substantiating ratings of this nature but are limited at this time.

Improved standards on fuel and labor requirements, machinery costs, labor charges, anticipated future prices and related data will assist in increasing the dependability of the budgets employed. Finally, information relating to the management practices and type-of-farming which prevails in the area to be rated is necessary if the evaluations are to represent prevailing conditions.

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APPENDIX

Application of the Method in Allen County

A preliminary application of the method used in Nemaha County was made in Allen County, Kansas. Information on soil types, relative productivity ratings and yields was provided by the Bureau of Plant Industry Soil Survey for Allen County.

The crop productivity indexes, as given, were converted to the same base as was used in the Nemaha County study. The physical yields and carrying capacities were converted to an evaluation in terms of economic rent by the same methods.

Time did not permit the development of a complete cropping system or set of management systems for the area. The rotations and techniques as determined for Nemaha County were considered reasonably applicable and were used to arrive at a tentative economic productivity evaluation. Production costs were based on calculated costs of production for similar soils in Nemaha County.

The physical crop productivity rating, estimated economic rent in native pasture and estimated economic rent in crops are shown by soil types in Table 16. This information is plotted in Fig. 8.

Estimated economic rent in crops increases 18.2 cents for every point the crop rating increases. This increase compares to 18.9 cents for comparable productivity increases in Nemaha County. The regression line for crop productivity

Table 16. Crop rating, economic rent per acre in crops and in native pasture, Allen County, Kansas.

Land type	General crop rating/1	Estimated economic rent	
		Crops/2	Pasture/3
Verdigris silt loam	91	10.26	1.58/4
Verdigris silty clay loam	91	10.26	1.58/4
Osage silt loam	91	10.26	1.58/4
Osage silty clay loam	87	9.46	1.58/4
Verdigris very fine sandy loam	81	8.50	1.32/4
Labette silt loam	75	7.44	2.07
Summit silty clay loam	70	6.41	2.32
Bates very fine sandy loam, deep phase	57	3.91	1.58
Newtonia silt loam	57	4.21	1.83
Labette silt loam, cherty phase	57	3.91	2.07
Woodson silty clay loam	66	5.44	2.07
Woodson silt loam	65	5.26	2.07
Parsons silt loam	50	2.81	1.58
Parsons silt loam, cherty-subsoil phase	50	2.81	1.58
Neosho silt loam	47	2.22	1.58
Parsons very fine sandy loam	40	1.07	1.32
Bates very fine sandy loam	38	.71	.84
Labette silt loam, shallow phase	48	2.32	1.83
Riverton silt loam, slope phase	42	1.24	1.32
Riverton silt loam	44	1.79	1.83
Summit-Bates complex/5			2.07
Summit stony silty clay/5			1.83
Labette stony clay loam/5			1.08
Newtonia stony loam/5			.84
Rough stony land (Summit soil material)/5			.35
Riverwash/5			.10

[1]Average of individual crop ratings weighted according to the frequency of each crop in a representative rotation for the county. Does not include soils for which adequate ratings had not been made.

[2]Gross income was determined on the basis of actual crop production and utilization as determined for Nemaha County. Expenses were estimated on the basis of costs for similar soils and rotations in Nemaha County with an additional amount to represent cost of fertilizer used to achieve the yields and ratings shown in the soil survey report.

[3]Pasture was utilized in the same manner as in Nemaha County.

[4]Ratings represent timbered areas and are not comparable to the other ratings.

[5]Not evaluated for crops because of its low productive capacity.

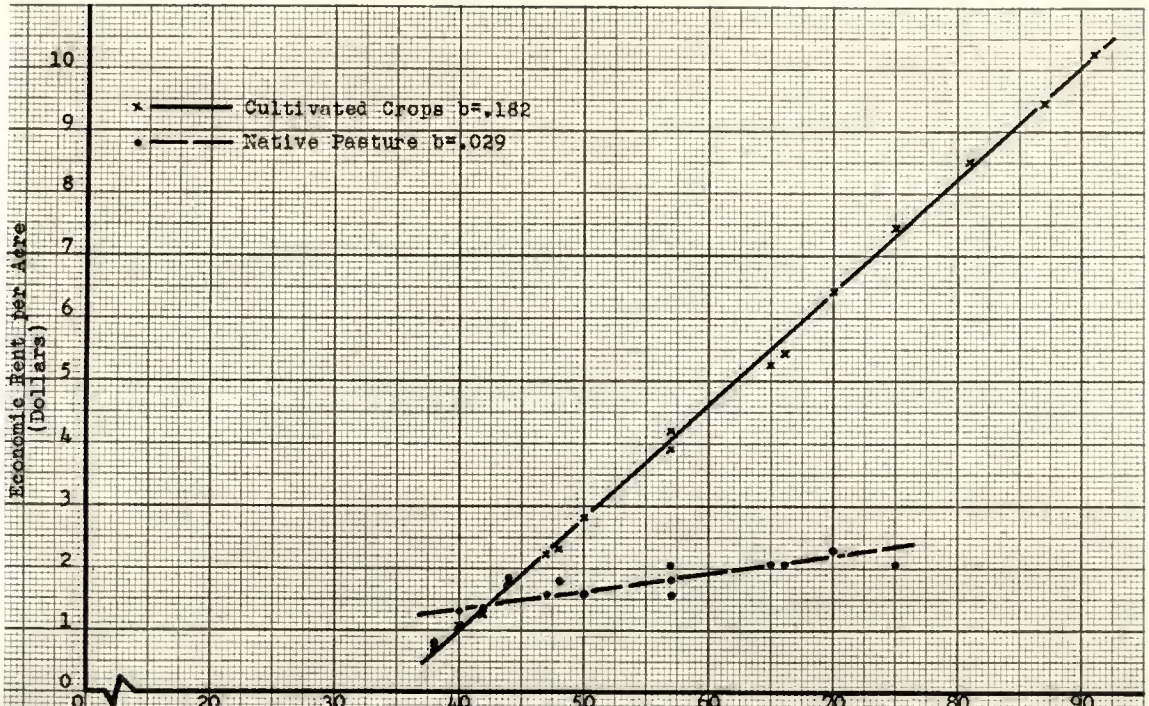

Figure 8. Economic rent per acre in cultivated crops and native pasture in relation to the relative crop productivity of land types in Allen County, Kansas.

crosses the zero economic rent line at a crop productivity rating of 35. This compares to a rating of 37 for Nemaha County and indicates that under Allen County conditions, soils of slightly lower productivity may be utilized profitably for crop production. This discrepancy results from the fact that Allen County soils are not adapted to exactly the same crops as are Nemaha County soils. The relationship between average yields of the several crops is not the same in the two counties.

Estimated economic rent in native pasture increases 2.9 cents for every point the crop rating increases. The values, when plotted, do not appear to have any particular tendency toward curvilinearity. It is believed that this results from the fact that only the intermediate range of productivity has been included. Pasture ratings for the better crop soils are not comparable and no crop ratings are available for the poorer soils. These limitations prevent the plotting of pasture productivity data for the extremes in cropland productivity. If these values could be included, the tendency toward curvilinearity shown by the Nemaha Study probably would exist. This is borne out by the fact that several of the soils considered too low in productivity to merit a rating for crop production show substantial economic returns when used for native pasture.

The regression line for economic productivity in native pasture crossed the regression line for crop productivity at

a crop productivity rating of 42. The intersection point as determined under Nemaha County conditions was 46. This indicates that crops may be produced in preference to native pasture on relatively poorer soils in Allen County. The advantage of crop production in Allen County is the result of the diminished productivity of pastures in relation to the productivity of crops on given soil types.

This study has been of a preliminary nature. A specific and detailed consideration of Allen County conditions might indicate the desirability of using other management systems more typical of that particular area. It does indicate the manner in which the principles and techniques employed may be applied to any sample area if the local details of prices, costs, land use and management systems are adapted to the method.